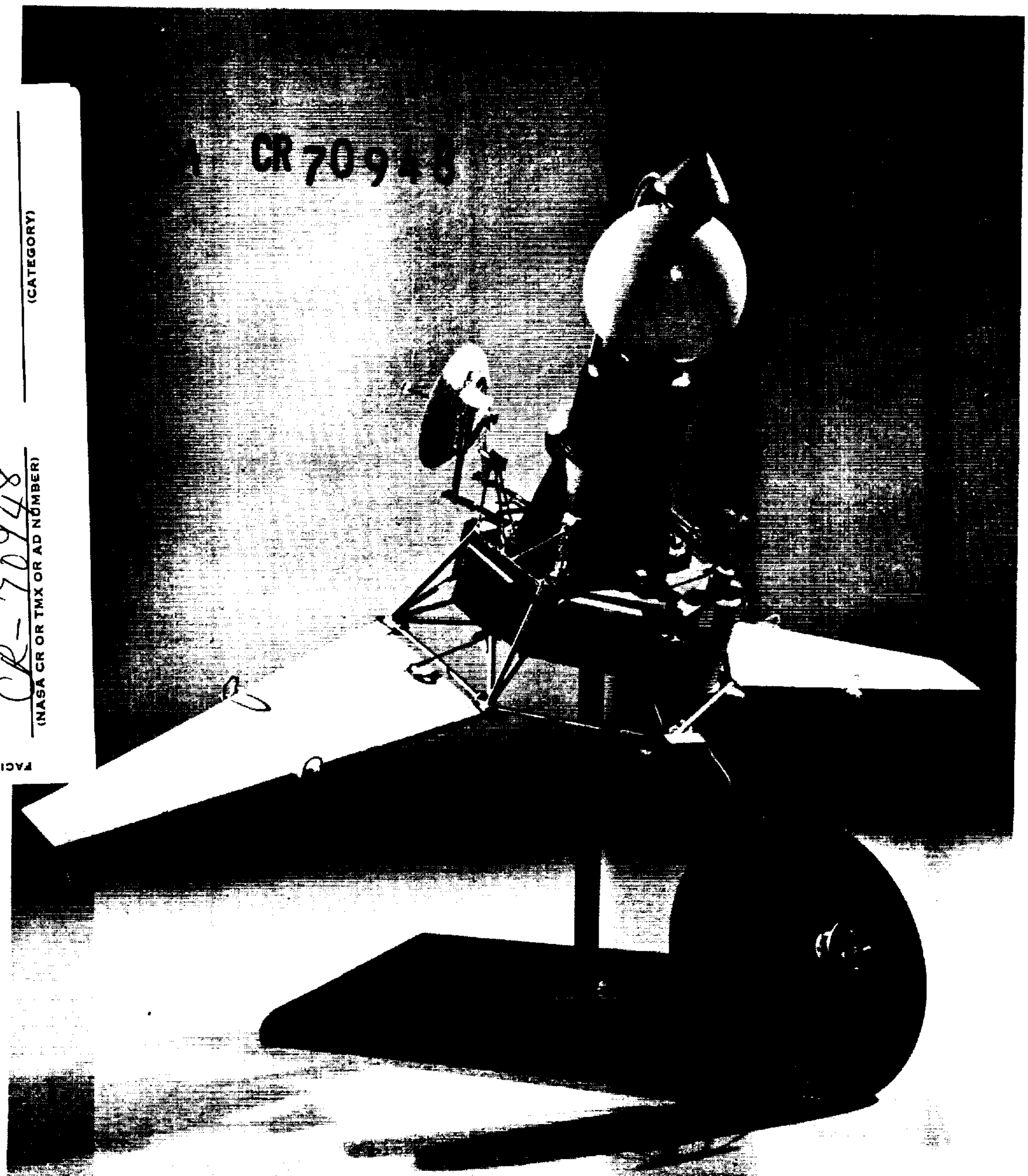
# MODEL SPACECRAFT CONSTRUCTION





REPORT SUBMITTED MAY 28, 1964

# Preface

The material presented by the committee was developed for the purpose of advancing the use of aerospace education in the secondary schools. This was prepared primarily for the fields of industrial arts and physical science. However, it need not be limited entirely to those two areas as it can be used in any subject matter area where the teacher and the student have the background necessary to interpret the plans and procedure sheets.

The project was developed as a suggested procedural pattern with the intent that it be adapted to fit the existing situation. The recommended materials and procedures are only guide lines. The committee urges the student to do experimentation and apply scientific principles to problem solving techniques in developing any of the model spacecraft.

The development of spacecraft models should be an interdisciplinary experience which encourages experimentation and research. There are numerous approaches to be used in constructing the models and these should challenge the student.

Students are encouraged to use this material to stimulate their thinking, experiment with new materials and processes, utilize as many tools as possible in the construction, develop accuracy and learn to follow outlined instructions.

## Introduction

Space exploration is still in its infant years. The achievements of the first years of the Space Age, however, have been phenomenal. Some of the "incredibles" of a short time ago are now a matter-of-fact part of our lives. Continued research will bring a greater accumulation of knowledge as the mysteries of the universe are unraveled.

This project covers a very small part of this vast program. At best it can only provide "a look into space". How much the participant sees in the project - reading and building models - and how much he sees beyond the project must necessarily be up to him. It is the hope that once his mind is opened to the wonders of space he will answer to its challenge.

The first real look into space may be an important one for it can be the starting point for someone whose vision can be developed into concepts as yet undreamed. Or it may be important just to give others a better understanding of our world.

Using this material as a stimulus it is hoped that this will encourage the student to delve deeper into the many unknowns related to the field of space education. This is only a springboard from which to launch the program. If it is wisely used one can only guess what the end results might be.

If this project serves to excite only a few into going farther into the study of the mysteries of space it will have been well worth the time and effort expended. For from the youth of today come the men of tomorrow who will carry forth with the adventures of space and the control of man's future.

## Acknowledgements

Spacecraft Construction, an incentive guide in aerospace education for secondary teachers was an outgrowth of the Aerospace Education Workshop at Long Beach State College, Long Beach, California, in August 1963. The material was developed through the efforts of nine teachers selected on the basis of their ability and background in the design and construction of aerospace models. The project was supported by the National Aeronautics and Space Administration.

The material on Spacecraft Construction was made possible through the efforts of the following individuals: Mr. Floyd M. Grainge, Professor of Industrial Arts, Long Beach State College, Long Beach, California; Mrs. Dorothy DeBord, Secretary, Applied Arts and Sciences Division, Long Beach State College, Long Beach, California; Miss Toshiko Goto, Art Instructor, Jordan Senior High School, Long Beach, California; Mr. Jack Kerner, Graduate Student, Long Beach State College, Long Beach, California; Mr. Richard L. Krahenbuhl, Industrial Arts Teacher, Bancroft Junior High School, Long Beach, California; Dr. Irvin T. Lathrop, Associate Professor of Industrial Arts, Long Beach State College, Long Beach, California; Mr. Howard B. Levine, Industrial Arts Teacher, LaHabra High School, Fullerton, California; Mr. Arthur Steiner, Vice Principal, Dewey Continuation High School, Long Beach, California; Mr. Ray Young, Graduate Student, Long Beach State College, Long Beach, California.

In expressing my appreciation I would like to thank Mr. Everett E. Collin, Chief, Educational Services Branch, National Aeronautics and Space Administration; Mr. Arthur L. Costa, Chief, Educational Programs Branch, Western Operations Office, National Aeronautics and Space Administration, and staff members of the Western Operations Office, National Aeronautics and Space Administration for their valuable assistance in guiding and reviewing the project through its formative stages. I would also like to thank the teachers in the field and graduate students at Long Beach State College who assisted in the review of the material for basic concepts and procedures. Without the assistance of these fine critics the project would not have been completed so readily for use in aerospace education. Our hope is that this project will provide a real stimulus for the implementation of advanced work in the area of aerospace education in the secondary schools.

C. Thomas Dean

C. Thomas Dean
Project Director

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# S A T U R N

With what envy man watched the birds wing through the air! He watched how they rose from the ground. He watched how they flew down from the trees. He watched the mighty ones soar and swoop. He studied in detail every one. If only he, too, could fly!

When Saturn V blasts Apollo on its mission, the astronauts might well smile as they remember this ancient wish. Without this wish, however, they might not be navigating through space; for space travel had to start with the wish of a dreamer. Daedelus, we are told, built wings of bird feathers and wax to escape from Crete. DaVinci's dream was more concrete. He only needed an engine to fly. The Wright brothers made the dream come true. Their memorable flight at Kitty Hawk started a continuing program of research and development in aerodynamics.

However, the first serious consideration of space flight probably grew out of the development of the rocket as a means of propulsion. The rocket is believed to have been introduced by the Chinese as early as the 13th century. They used powder rockets to direct "fire arrows" at the Mongols during the seige of Kaifeng. During the next five centuries, rockets were chiefly used for fireworks. About 1800, Congreve in England developed a solid fuel war rocket which led to its widespread military use.

Practical studies of using rocket propulsion for space flight started near the end of the 19th century. Konstantin Ziolkowsky, a Russian mathematics teacher; Herman Ganswindt, a German law student, and Robert Esnault-Pelterie of France did considerable theoretical work on space flight and rocket propulsion.

The generally acknowledged father of space flight, Dr. Robert H. Goddard of the United States, translated the dream and the theory into hardware. He conducted extensive research in rocketry between 1914 and World War II. On March 16, 1926, he successfully tested the world's first liquid fuel rocket.

Although Dr. Goddard continued his work until his death, he failed to arouse enthusiasm in the United States. In Europe, however, rocket power gained new impetus. The German army started a research program which culminated in the famed Peenemunde project and the V-2 missile, a 46-foot rocket of 200-mile range used to bombard London from the continent. This V-2 is the modern forerunner of our current boosters.

The rocket is the only power plant presently capable of traveling through interplanetary space. Although it is basically an internal combustion engine, it differs from all others in one respect. It carries its own oxydizer and therefore can operate in a vacuum. The rocket is also the only engine capable of producing propulsive power while moving at very high velocities. It is important as a booster because at present the rocket engine develops the greatest thrust per pound of engine weight and has the smallest frontal area per unit of thrust of all power plants.

Very high speed is necessary to travel into space. A satellite can be placed in earth orbit at the speed of 18,000 miles per hour.

By increasing the speed to 25,000 miles per hour, the gravitational pull of the earth can be overcome. To place a 90,000 pound spacecraft into translunar trajectory, then, requires a tremendous amount of power. This is the mission of Saturn V, the three stage rocket which is to boost Apollo to the moon.

The first stage of Saturn V will be powered by five F-I engines. Each is capable of delivering 1 1/2 million pounds of thrust and consumes 3 tons of liquid oxygen and kerosene every second. Largest of such engines being developed in the United States, it stands 18 feet high and weighs 10 tons. This first stage, the S-1C itself, will weigh 140 tons empty and over 2,300 tons fueled. It will be 33 feet in diameter and stand 138 feet tall.

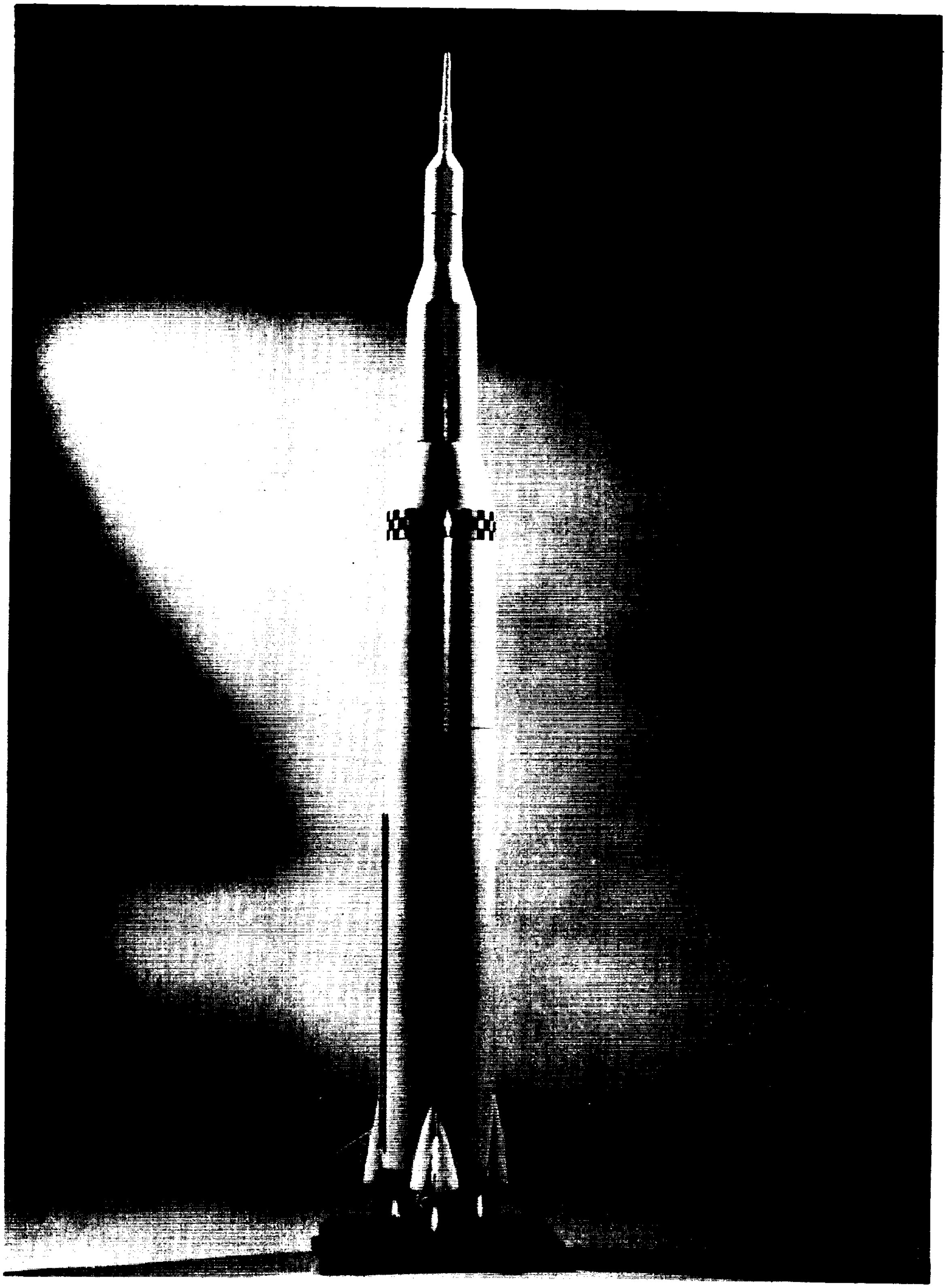
The second SII stage to be propelled by liquid hydrogen and liquid oxygen will deliver 1,000,000 pounds of thrust with its five J-2 engines. Being equal in diameter, 81 1/2 feet in height, and weighing 37 1/2 tons, it will ride atop the first stage.

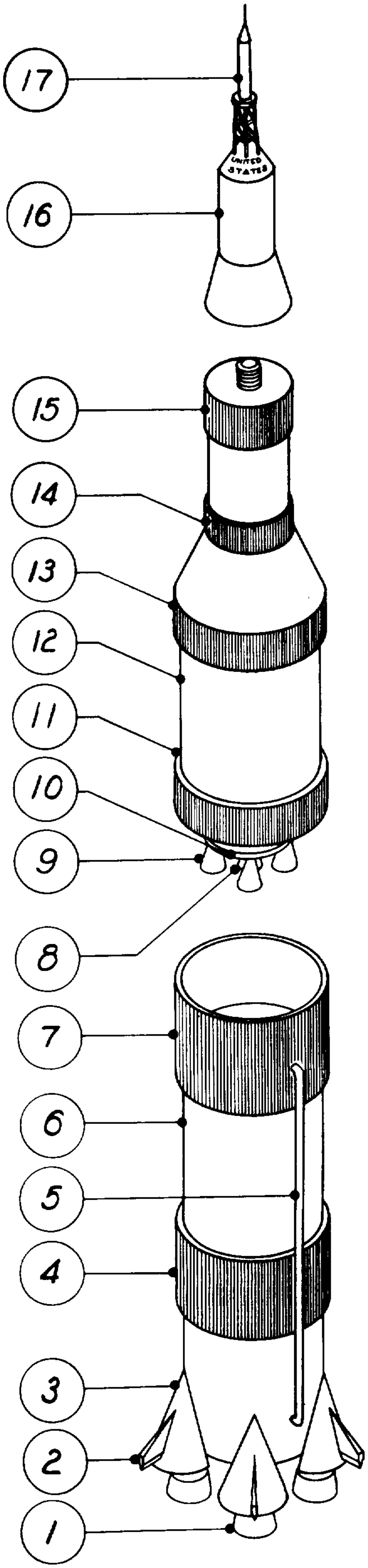
The S-IVB will be powered by a single J-2 engine with the thrust of 200,000 pounds. It will serve as the third stage of the Saturn V, the vehicle which will send the Apollo spacecraft on its mission to the moon.

Chemical combustion is presently used in rocket propulsion because no other means of accelerating mass to high exhaust speeds has been perfected. Other promising systems now under study include: nuclear fission, nuclear fusion, ion power, arc heating, solar power, and photon power.

To every action there is an equal and opposite reaction. Newton's third law translated to hardware, then, is surely man's passport to space.

SATURN






# PARTS LIST- SATURN V ROCKET & APOLLO CAPSULE

| NO. | NAME | REQ'D. | MAT'L | COLOR |
|---|---|---|---|---|
| 1. | F-1 ENGINE | 5 | WOOD | WHITE |
| 2. | STABILIZING FIN | 4 | WOOD | WHITE |
| 3. | ENGINE SHIELD | 4 | WOOD | WHITE |
| 4. | S-IC ROCKET BAND | 1 | BALSA WD. | BLACK |
| 5. | FUEL LINE | 1 | $\frac{1}{16}$" BRS. ROD | POLISH |
| 6. | S-IC 1ST STAGE | 1 | WOOD | WHITE |
| 7. | S-IC ROCKET BAND | 1 | BALSA WD. | BLACK |
| 8. | J-2 ENGINE | 1 | STEEL | WHITE |
| 9. | J-2 ENGINE | 4 | WOOD | WHITE |
| 10. | ENGINE MOUNT | 1 | WOOD | WHITE |
| 11. | S-II ROCKET BAND | 1 | BALSA WD. | BLACK |
| 12. | ROCKET-UPPER STAGE | 1 | WOOD | WHITE |
| 13. | S-II ROCKET BAND | 1 | BALSA WD. | BLACK |
| 14. | S-II ROCKET BAND | 1 | BALSA WD. | BLACK |
| 15. | S-II ROCKET BAND | 1 | BALSA WD. | BLACK |
| 16. | APOLLO CAPSULE | 1 | WOOD | WHITE |
| 17. | ESCAPE SYSTEM | 1 | METAL | WHITE |

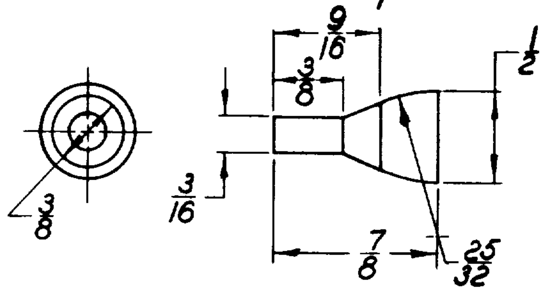
NOTES:

1.- S-IC ROCKET SECURED TO S-II ROCKET BY A 10-24 THREADED ROD AS SHOWN ON DETAILS.

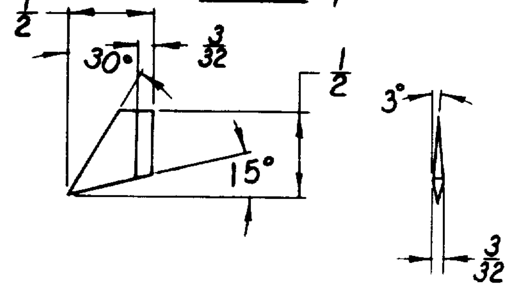
2.- APOLLO CAPSULE SECURED TO S-II ROCKET BY $\frac{1}{4}$-20 THREADED ROD - SEE DETAILS.

3.- ALL PAINTED SURFACES-HAND RUBBED AND WAXED.

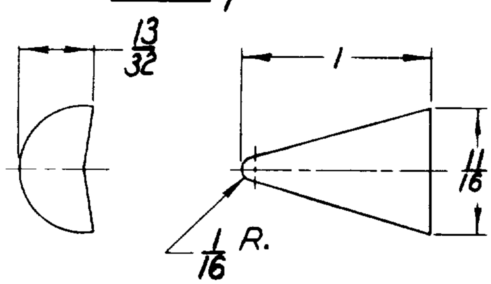
DETAIL NO. 1
SCALE 2/1



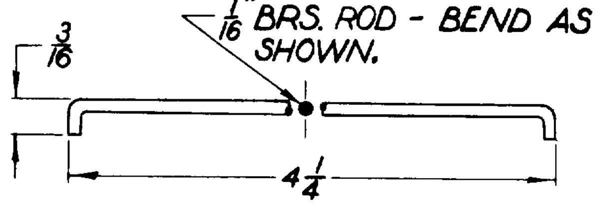

DETAIL NO. 2
SCALE 2/1

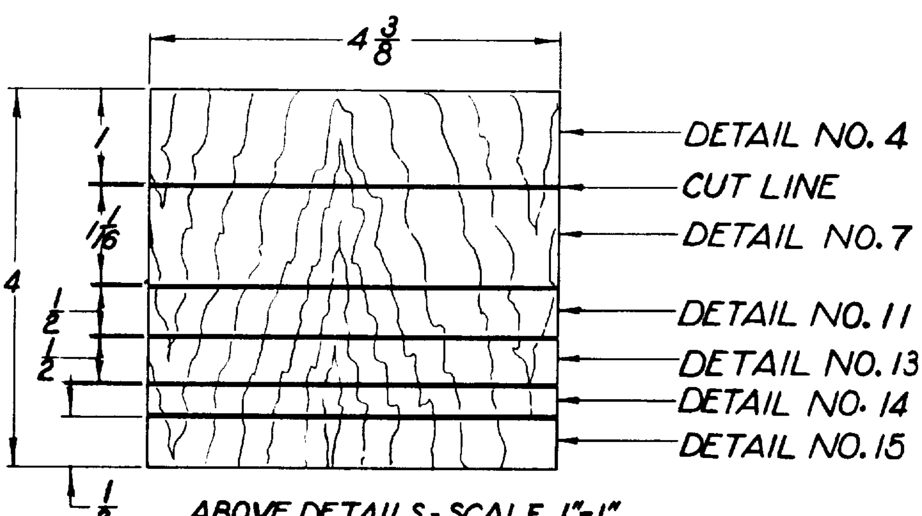



DETAIL NO. 3
SCALE 2/1




DETAIL NO. 5
SCALE 2/1



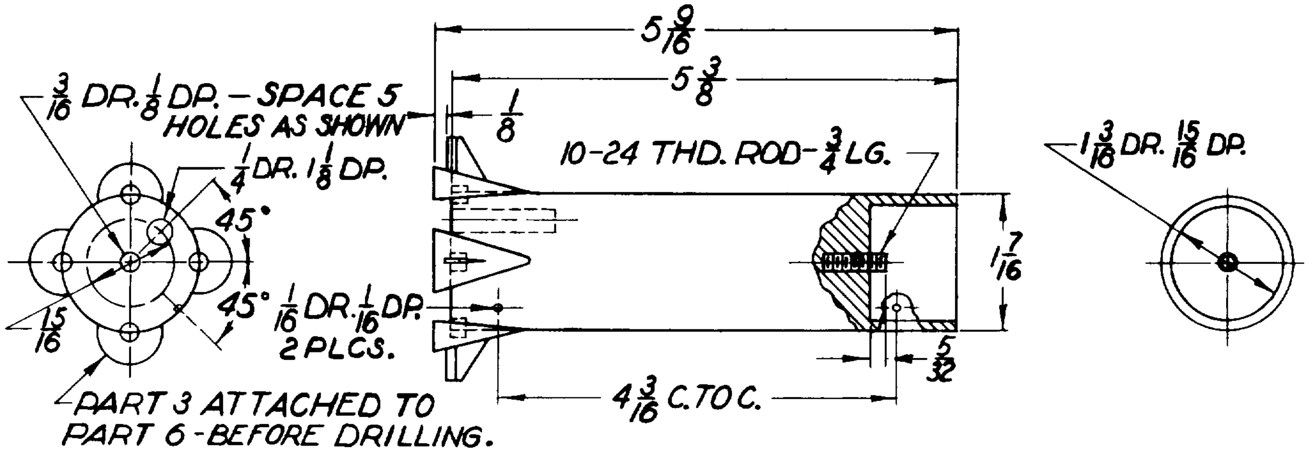




ABOVE DETAILS - SCALE 1"=1"

NOTES:
1.- MATL. 1/32" BALSA WD. LAYOUT WITH GRAIN PATTERN AS SHOWN.
2.- PAINT BANDS BLACK BEFORE CEMENTING IN PLACE.

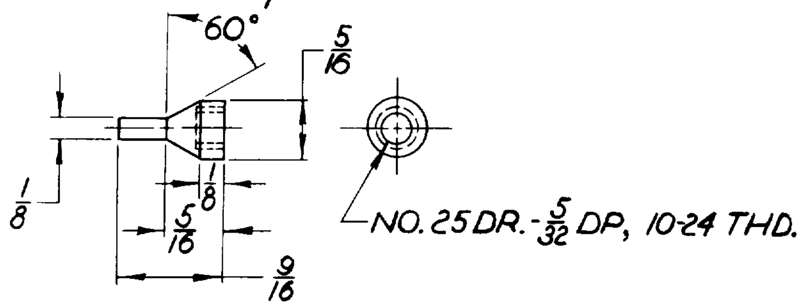
DETAIL NO. 6

SCALE 1"=1"



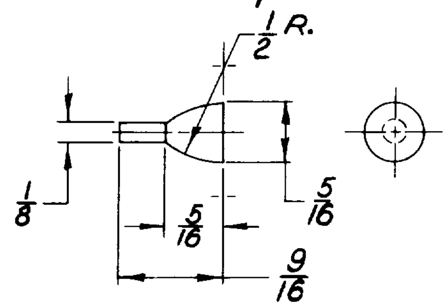

DETAIL NO. 8

SCALE 2/1




DETAIL NO. 9

SCALE 2/1




DETAIL NO. 10

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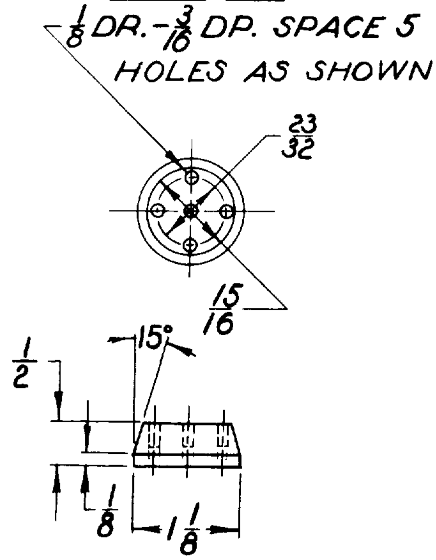


DETAIL NO. 12

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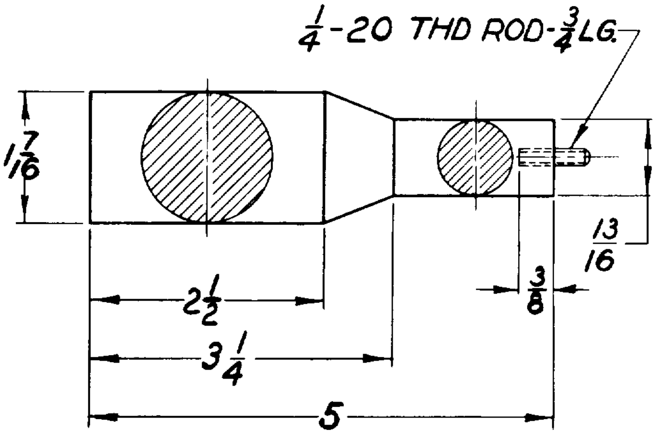

DETAIL NO. 16
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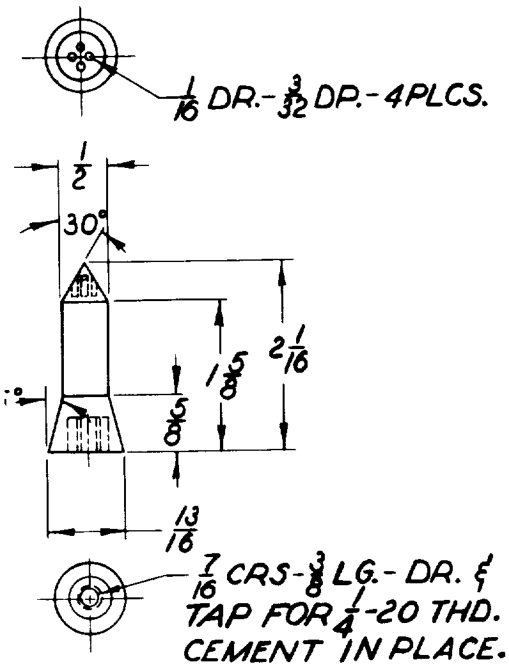
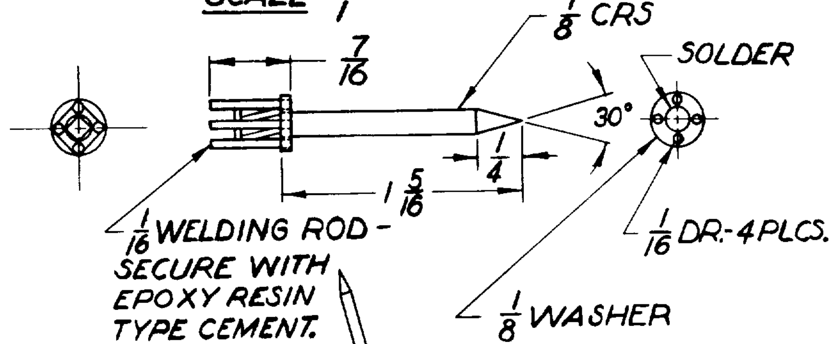
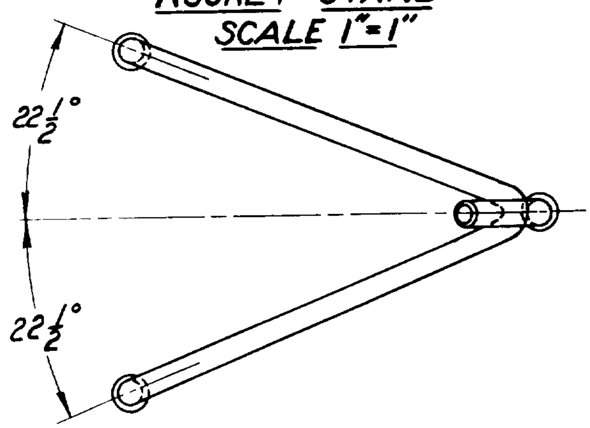


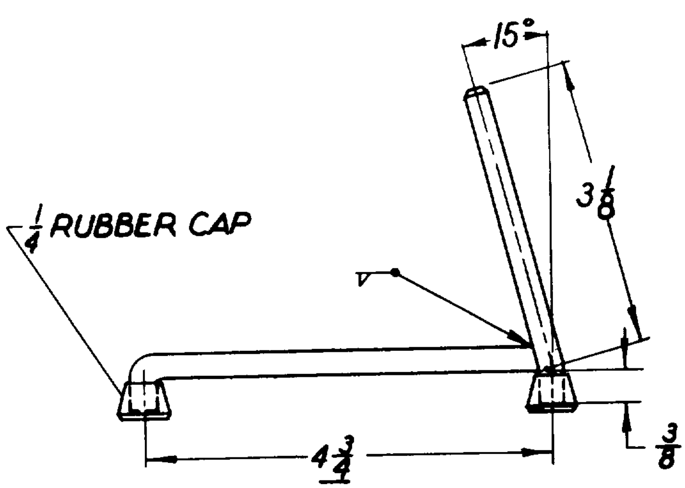

DETAIL NO. 17
SCALE 2/1

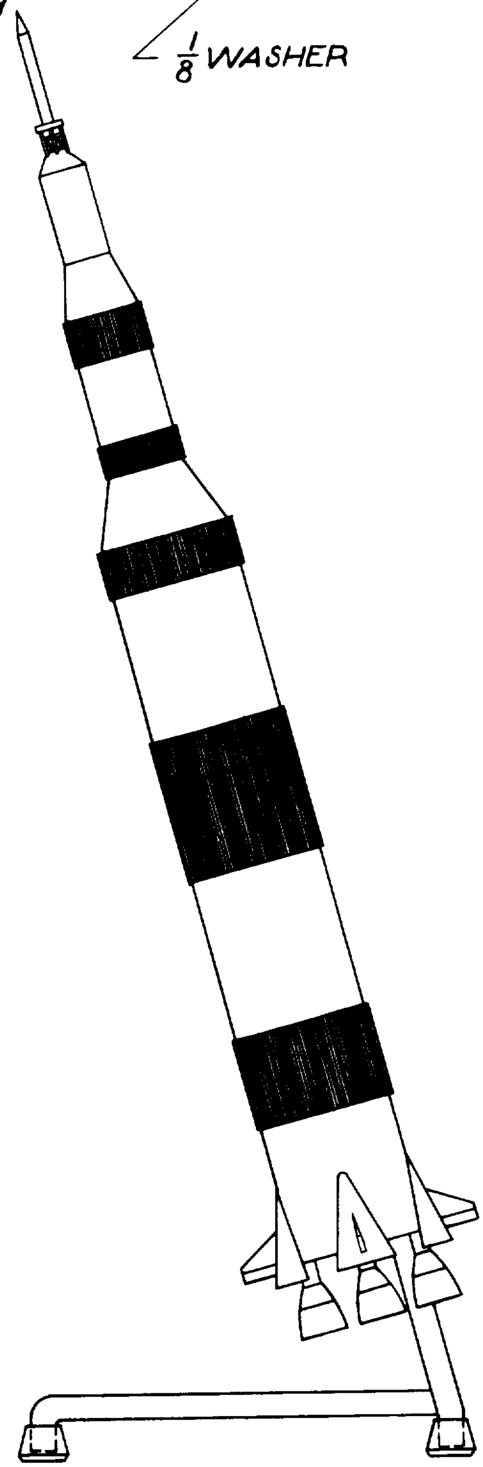



ROCKET STAND
SCALE 1"=1"




1/4 CRS-BEND AS SHOWN.



RECOMMENDED MATERIALS FOR CONSTRUCTION

SATURN V

| PART NUMBER | NUMBER REQUIRED | RECOMMENDED MATERIAL | COLOR |
|---|---|---|---|
| 1 | Five | Wood - pine | White |
| 2 | Four | Wood - pine | White |
| 3 | Four | Wood - pine | White |
| 4 | One | Wood - balsa | Black |
| 5 | One | Metal - brazing rod | Polish |
| 6 | One | Wood - pine | White |
| 7 | One | Wood - balsa | Black |
| 8 | One | Metal - rod | White |
| 9 | Four | Wood - pine | White |
| 10 | One | Wood - pine | White |
| 11 | One | Wood - balsa | Black |
| 12 | One | Wood - pine | White |
| 13 | One | Wood - balsa | Black |
| 14 | One | Wood - balsa | Black |
| 15 | One | Wood - balsa | Black |
| 16 | One | Wood - pine | White |
| 17 | One | Metal - rod | White |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

SATURN V

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 1 | Wood | Turn on lathe to specified dimensions | Finish sand all surfaces | |
| 2 | Wood or plastic | Cut and shape to specified dimensions | Finish sand all surfaces | |
| 3 | Wood or plastic | Turn on lathe to specified dimensions and saw to shape | Finish sand all surfaces | Glue part no. 2 to part no. 3 using epoxy resin |
| 4, 7, 11, 13, 14, 15 | Balsa wood or cardboard | Cut and fabricate to specified dimensions and detail | Paint black prior to cementing to the main body | |
| 5 | Brass rod | Shape to specified dimensions | Polish | |
| 6 | Wood | Turn on lathe to specified dimensions. Drill as indicated on the detail drawing | Finish sand all surfaces | Glue parts no. 1, 3, 4, 7 and 5 to part no. 6 using epoxy resin |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

SATURN V

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 8 | Steel or brass | Turn on lathe to specified dimensions. Drill and tap as indicated on the detail drawing | Polish | |
| 9 | Wood | Turn on lathe to specified dimensions | Finish sand all surfaces | |
| 10 | Wood | Turn on lathe to specified dimensions. Drill as indicated on the detail drawing | Finish sand all surfaces | |
| 12 | Wood | Turn on lathe to specified dimensions. Drill as indicated on the detail drawing | Finish sand all surfaces | Glue parts no. 8, 9,10,11,13,14 and 15 to part no. 12. Glue treaded rod into position using epoxy resin |
| 16 | Wood | Turn on lathe to specified dimensions. Drill as indicated on the detail drawing | Finish sand all surfaces | Glue threaded bushing into place using epoxy resin |

## RECOMMENDED PROCEDURE FOR CONSTRUCTION

### SATURN V

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIOUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 17 | Steel or brass | Fabricate parts to dimensions and details indicated in detail no. 17 | | Cement to part no. 16 using epoxy resin |
| | | | Paint parts no. 1, 2,3,6,8,9,10,12,16 and 17 white | |

E X P L O R E R

Twinkle, twinkle, little star;
How I wonder what you are!
Up above the world so high.
Like a diamond in the sky.*

Why do you twinkle? What are you doing there? Who put you there? Man's natural curiosity has led him on a never-ending search for answers to the mysteries of his universe.

Until recently our only source of information about outer-space lay entirely on light and other radiation that penetrated earth's atmosphere from the vastness of the universe. This atmosphere that makes the stars seem to twinkle obscures and distorts our vision. Through the use of sounding rockets, we have been able to gather information in outer space. These rockets are relatively small, relatively inexpensive vehicles for lofting simple payloads from a few score to a few thousand miles above the earth's surface. In the few minutes of flight before the rocket plunges back to earth, the payload instruments measure the selected properties of space. This technique highly developed in the decade following World War II was the only technique for on-site measurements of space until satellite flight was achieved in 1957.

Although the sounding rocket remains a basic tool for acquiring local instantaneous measurements of space properties, the satellite is our major tool for acquiring long-term measurements. It is possible to

*"The Little Star" Jane Taylor

gradually acquire a basic understanding of the space in all directions at distances up to several hundred thousand miles by varying the orbital inclination and the ellipticity of the satellite paths.

The Explorer program consists of geophysical satellites of various configurations to study the space environment and upper atmosphere surrounding the earth. Various payload instruments study such phenomena as radiation, micrometeoroids, temperatures, magnetic field and solar plasma.

Early in 1958 Van Allen discovered an additional layer of particles in the upper atmosphere by the analysis of geiger counter data from Explorer I. Until this time it was believed that the density of the upper air merged into the density of the interplanetary gas at an altitude of about 1,000 km. and that this marked the boundary of the atmosphere. This layer, eventually found to reach out to about 100,000 km., is called the magnetosphere because it exists only by virtue of the presence of the earth's magnetic field. This discovery was the most significant discovery of the IGY (International Geophysical Year).

Since the discovery of the Van Allen radiation belt, there has been a large number of investigations of these particles by sounding rockets and satellites. Explorer XII, the energetic particles satellite, added significantly to the radiation belt studies. Launched on August 15, 1961, into a highly eccentric orbit (apogee 48,000 miles perigee 182 miles), it transmitted data until December 6, 1961. It passed through the belt twice per orbit for a total of 204 transits.

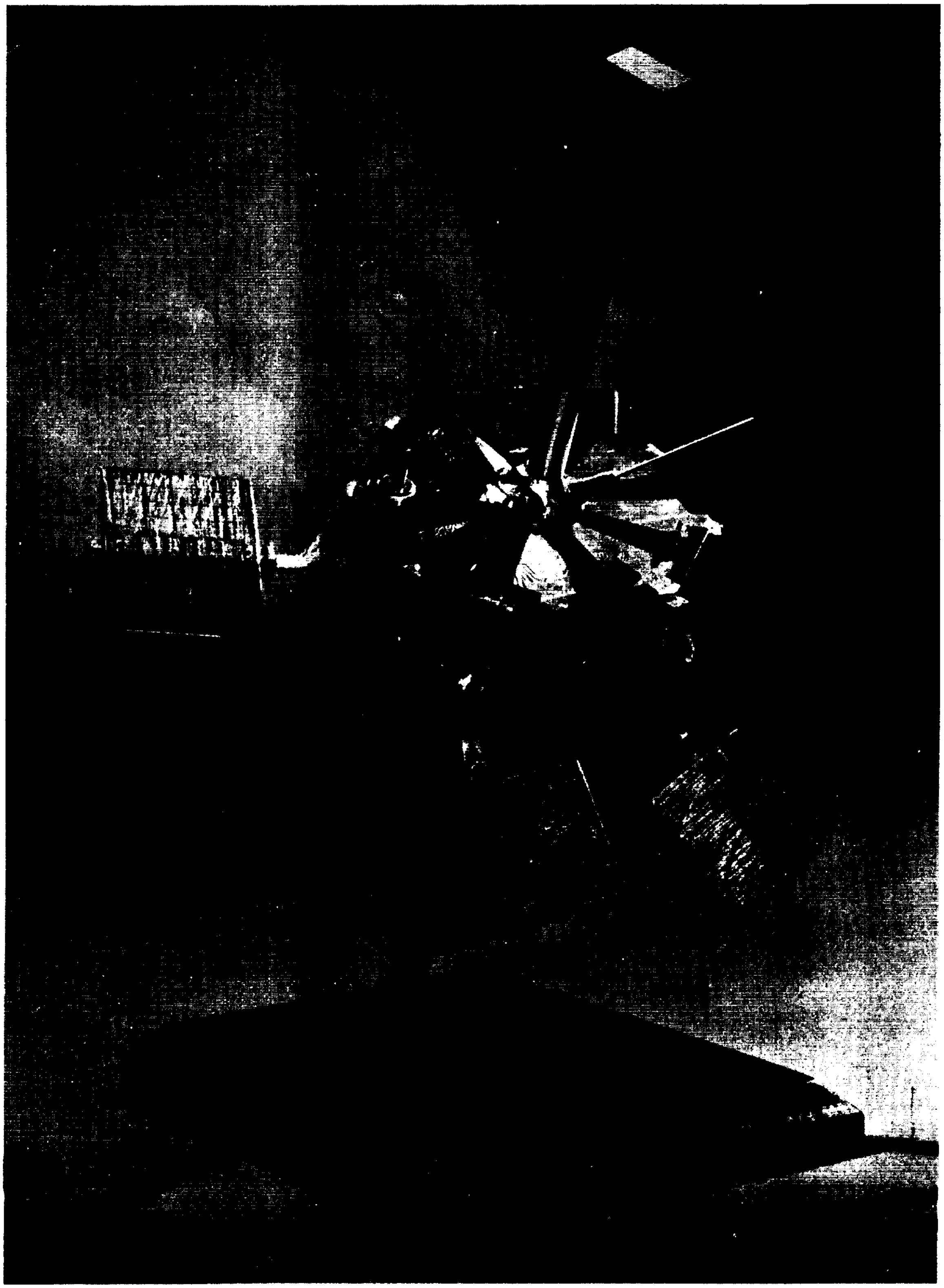
The instruments on the satellite revealed a large flux of medium-energy protons trapped in the outer zone of the radiation belt. No protons had been detected in the previous measurements and it was believed that the belt was populated only by electrons. The instruments also indicated that the level of electron flux in the outer Van Allen belt was about three orders lower than what had been previously considered to be present.

Such investigations have added much to the understanding of the phenomena of outer space but the most remarkable feature of the program has been its interdisciplinary nature. Science disciplines such as physics, astronomy, and geophysics that had gone their separate ways now attack space problems in close partnership.

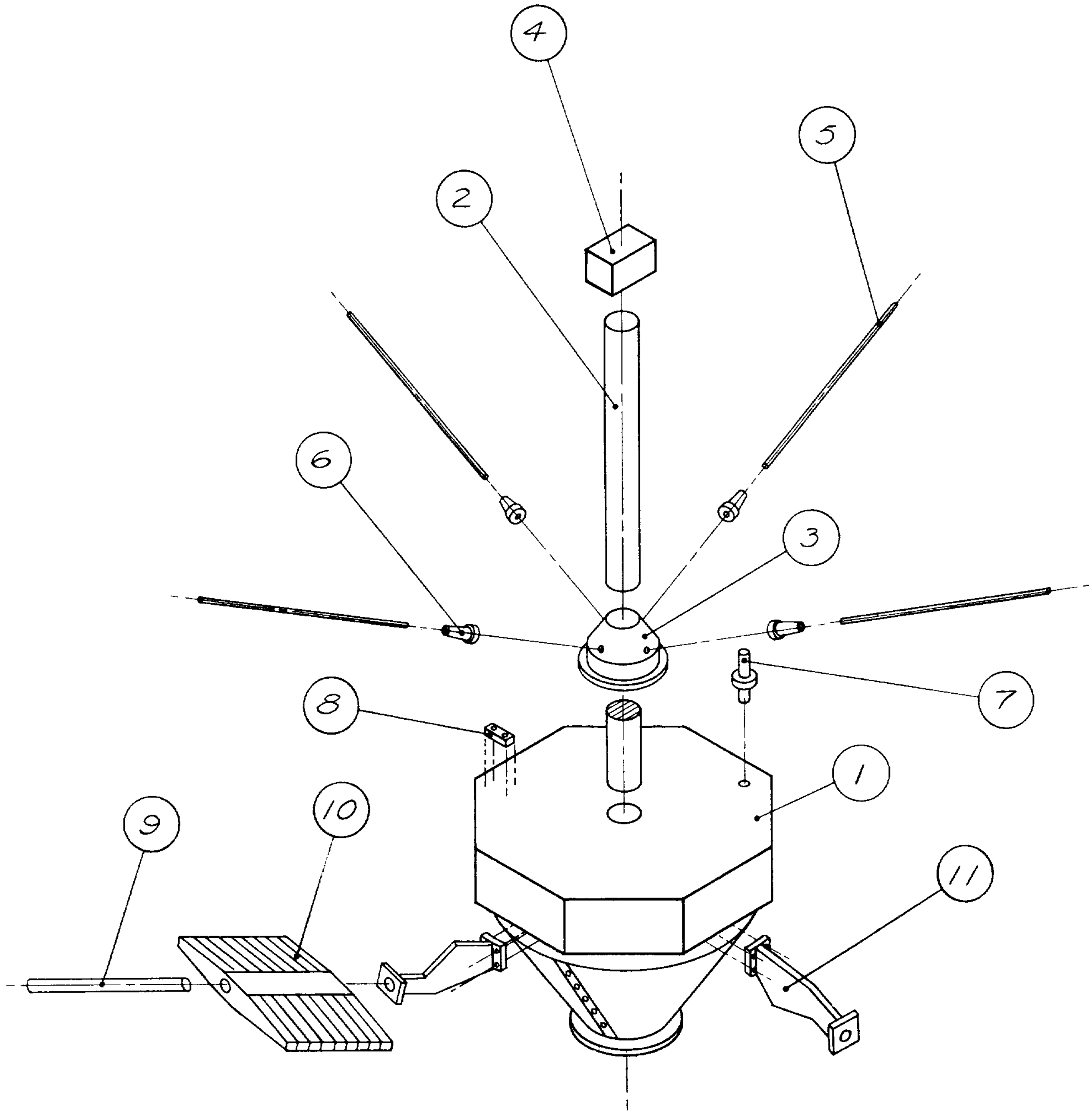
With cooperative effort and our new found ability we have been able to reach out to the stars. In many instances the measurements increased our knowledge of space but we also learned more about the earth itself. In some cases we learned very new and very fundamental facts about the distant stars.

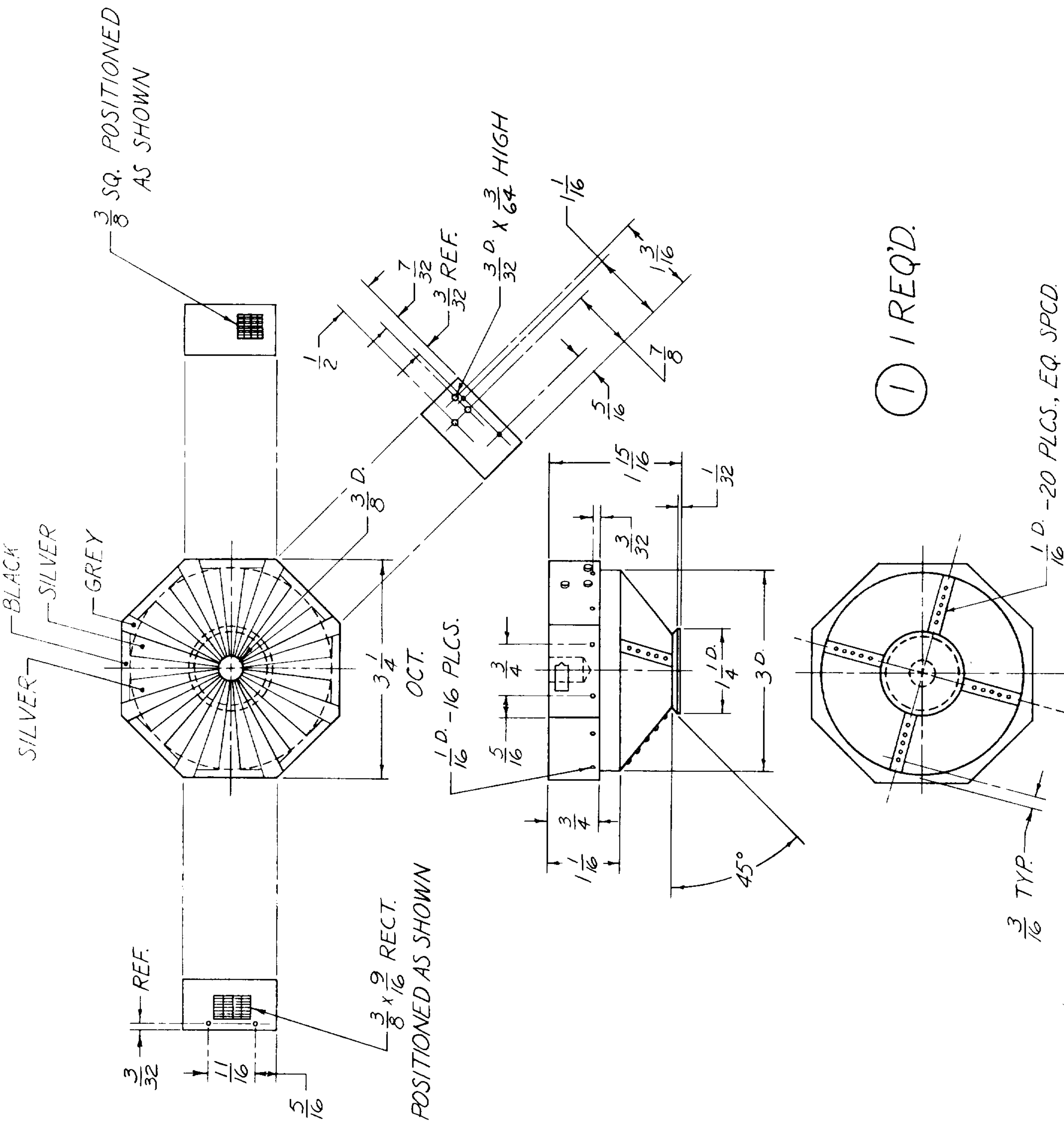
Twinkle, twinkle, little star, we'll soon find out what you are.

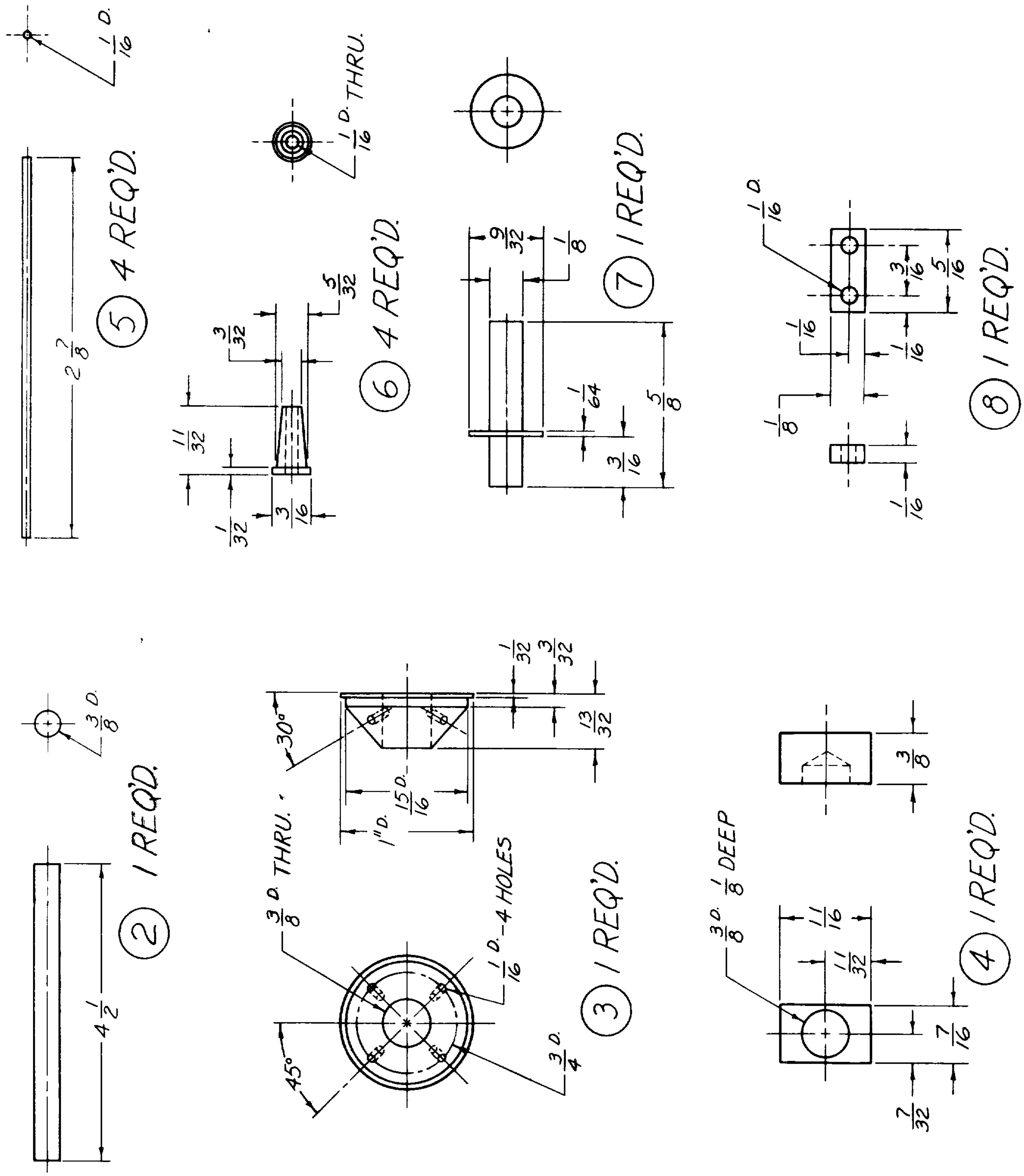
## EXPLORER

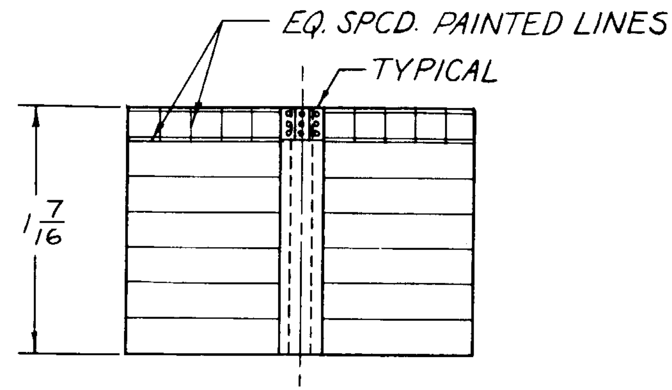


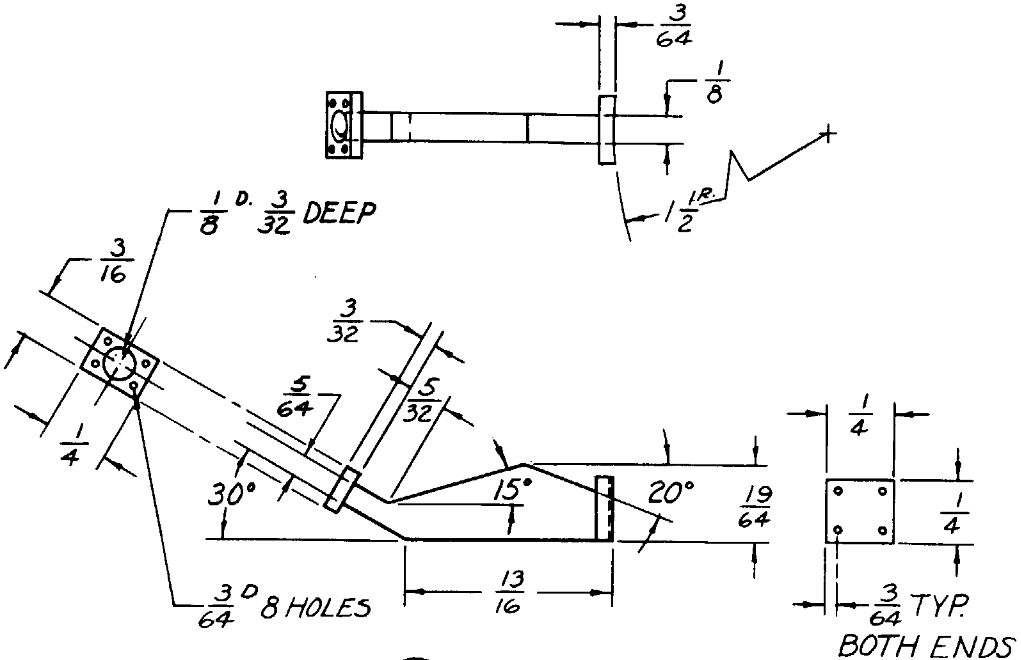
# ~EXPLORER XII~
# ASSEMBLY




3/8 SQ. POSITIONED AS SHOWN
1/2
7/32
3/32 REF.
3/32 D. X 3/64 HIGH
1 1/16
1 3/16
7/8
5/16
3/8 D.
BLACK
SILVER
GREY
SILVER
3 1/4 OCT.
1/16 D. -16 PLCS.
3/4
5/16
1 15/16
1/32
3/32
1/4 D.
1 1/4
3 D.
3/4
1 1/16
45°
1 REQ'D.
1/16 D. -20 PLCS., EQ. SPCD.
15° TYP.
3/16 TYP.
REF.
3/32
11/16
5/16
3/8 x 9/16 RECT. POSITIONED AS SHOWN


5 4 REQ'D.
6 4 REQ'D.
7 1 REQ'D.
8 1 REQ'D.
2 1 REQ'D.
3 1 REQ'D.
4 1 REQ'D.

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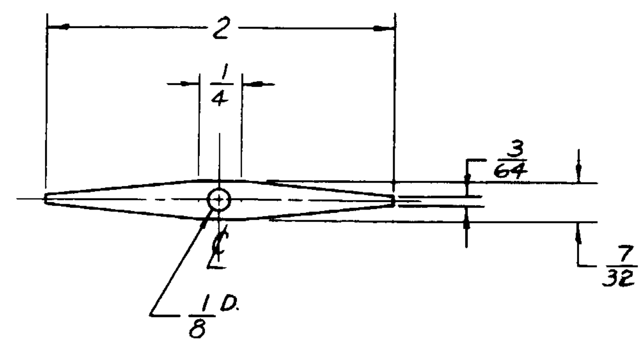


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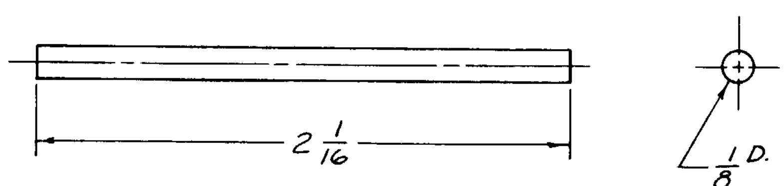



(9) 4 REQ'D.

RECOMMENDED MATERIALS FOR CONSTRUCTION

EXPLORER XII

| PART NUMBER | NUMBER REQUIRED | RECOMMENDED MATERIAL | COLOR |
|---|---|---|---|
| 1 | One | Wood - pine | Silver with black surface details |
| 2 | One | Dowell - rod, metal or plastic rod, metal or plastic tubing | Silver |
| 3 | One | Wood - (maple), plastic or brass | Silver |
| 4 | One | Wood - (maple) or plastic | Yellow |
| 5 | Four | Metal brazing rod | Silver |
| 6 | Four | Wood - (maple) or plastic | Silver |
| 7 | One | Metal brazing rod and washer | Gold |
| 8 | One | Wood - (balsa) or sheet metal | Red |
| 9 | Four | Dowel - rod or brazing rod | Silver |
| 10 | Four | Wood - balsa or pine | Silver with black surface details |
| 11 | Four | Sheet metal | Silver with black surface details |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

EXPLORER XII

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 1 | Wood - pine | Construct octagon bodyturn on lathe to specified dimensions. Drill all holes as per detailed drawing | Finish sand all surfaces | |
| 2 | Dowel - rod, metal or plastic rod, Metal or plastic tubing | Cut to length and square ends | | |
| 3 | Wood, plastic or brass | Turn to specified dimensions. Drill all holes as per detailed drawing | Finish sand or polish surface | |
| 4 | Wood or plastic | Construct to specified dimensions. Drill as per detailed drawing | Finish sand or polish surface | |
| 5 | Metal rod | Cut to specified length | | |
| 6 | Wood, plastic or brass | Shape on drill press or pencil sharpener<br>or<br>Machine on lathe | Finish sand<br><br>Polish surface | |
| 7 | Brazing rod and brass washer | Fit washer onto rod | Polish | |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

EXPLORER XII

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 8 | Balsa wood or sheet metal | Drill holes as per detailed drawing | | |
| 9 | Dowel - rod or brazing rod | Cut to specified length | | |
| 10 | Balsa wood or soft pine | Layout and fabricate to specified dimensions and sand tapers. (May be constructed as one piece and divided into four equal pieces) | Finish sand | |
| 11 | Sheet metal | Construct both ends separate from the main body. Drill as specified on detail no. 11. All 3/64D. holes to be painted. Solder both ends to the body. | | Assemble part no. 9 to part no.11 using epoxy resin or solder |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

EXPLORER XII

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| | | | | Attach part no. 11 to part no.1 as indicated on the assembly drawing by alternating the position of part no.11 |
| | | | Paint all parts silver except parts no. 7 and 8 | |
| | | | Apply surface details to part no. 1 as specified using appropriate paint or India ink | |
| | | | | Assemble part no. 7 to part no. 1 |
| | | | Simulate solar cells on part no. 10 by drawing equally spaced lines on the surfaces as indicated on detail no. 10 | |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

EXPLORER XII

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| | | | Paint part no.8 red and attach to part no. 1 with epoxy resin | |
| | | | | Attach parts no. 2,3,4,5 and 6 to part no. 1 |
| | | | Paint part no.4 yellow | |
| | | | | Assemble part no. 10 to part no. 9 |
| Model Stand | Wood - walnut | Design stand to support the assembled model | Natural rubbed oil finish | |

# O S O

## (ORBITING SOLAR OBSERVATORY)

When the daylight sky turns to night, astronomers scurry from all over the world to see the phenomenon. The bright disk of the sun disappears and the full glory of the corona becomes visible. The stars and planets shine through the varicolored hue. The wispy pearl-colored corona stretches out away from the sun for several diameters. At the base of the corona, crimson prominences can be seen twisting from the dark outline of the moon. This splendor of the total eclipse can only be seen within a small black area some 100 miles in diameter. It is the ambition of every astronomer to place himself in this small black spot.

Although eclipse expeditions have given us a fundamental knowledge of the sun, observational time has been short, for total eclipses are rare, occurring not more than two or three times a year. The spot travels at a speed of 2,000 miles per hour along the eclipse track. Although it can be accurately calculated beforehand, careful preparation of the observational program is necessary because the moon's shadow only spends a few seconds over the chosen site. Even if an astronomer can travel to every eclipse track, he only has a few minutes of working time available each year. If the equipment fails or if it is cloudy, he must then wait for months before it is possible to observe again. And then the next eclipse track may cross over inaccessible parts of the world.

Other important sources of knowledge are the solar observatories, such as the one in the Hollywood Hills, California. There the smog, which makes life miserable for the populace, serves as a perfect filter through which valuable photographs can be taken.

Now, with rockets and satellites, the research work can be extended out into space. Telescopes can be carried out into space above earth's atmosphere for a better look, just as the astronomers in the past carried theirs to the mountain tops.

The sun, the major source of energy in the solar system, controls the environment in space as well as the weather on the earth. It is fitting, then, that the first observatory-class satellite should be designed primarily for the study of solar physics.

Why does the sun have an 11-year sunspot cycle? What causes solar flares? How are the energetic particles accelerated to their high energies? Understanding of the sun itself is one of the objectives of solar physics.

Another objective is to monitor continuously the radiation from the sun. Scientists need these data to understand the measurements they make on the atmosphere and ionosphere of the earth, in interplanetary space, and on the other planets.

The Orbiting Solar Observatory (OSO) has taken data pertinent to these objectives. By making continuous measurements of the ultraviolet light and soft X-rays emitted by the sun, it has given data on the solar processes.

OSO-I on its 344/370 mile orbit points continuously at the center of the sun with an accuracy of $\pm$ 1/2 arc minute. The upper portion, called the sail, which points at the sun, carries the solar cells which provide the energy for the satellite. The bottom section of this 458 pound craft known as the wheel rotates to provide stability. In it are housed the batteries, telemetry and experiments which need not be pointed at the sun.

One of the major experiments in the pointed section was a spectometer to study the solar spectrum of the sun in the wave length region from 50 to 400 Å. This is the portion of the solar spectrum that controls the properties of the upper layer of the earth's ionosphere. All of these lights are absorbed at extremely high altitudes. Many clues about the properties of the chromosphere and the corona of the sun were obtained from this experiment.

Another major experiment was to measure the intensity of X-rays in the 1 to 8 Å region. It was possible to observe X-rays from very weak flares and in some cases those from flares not observed on the ground.

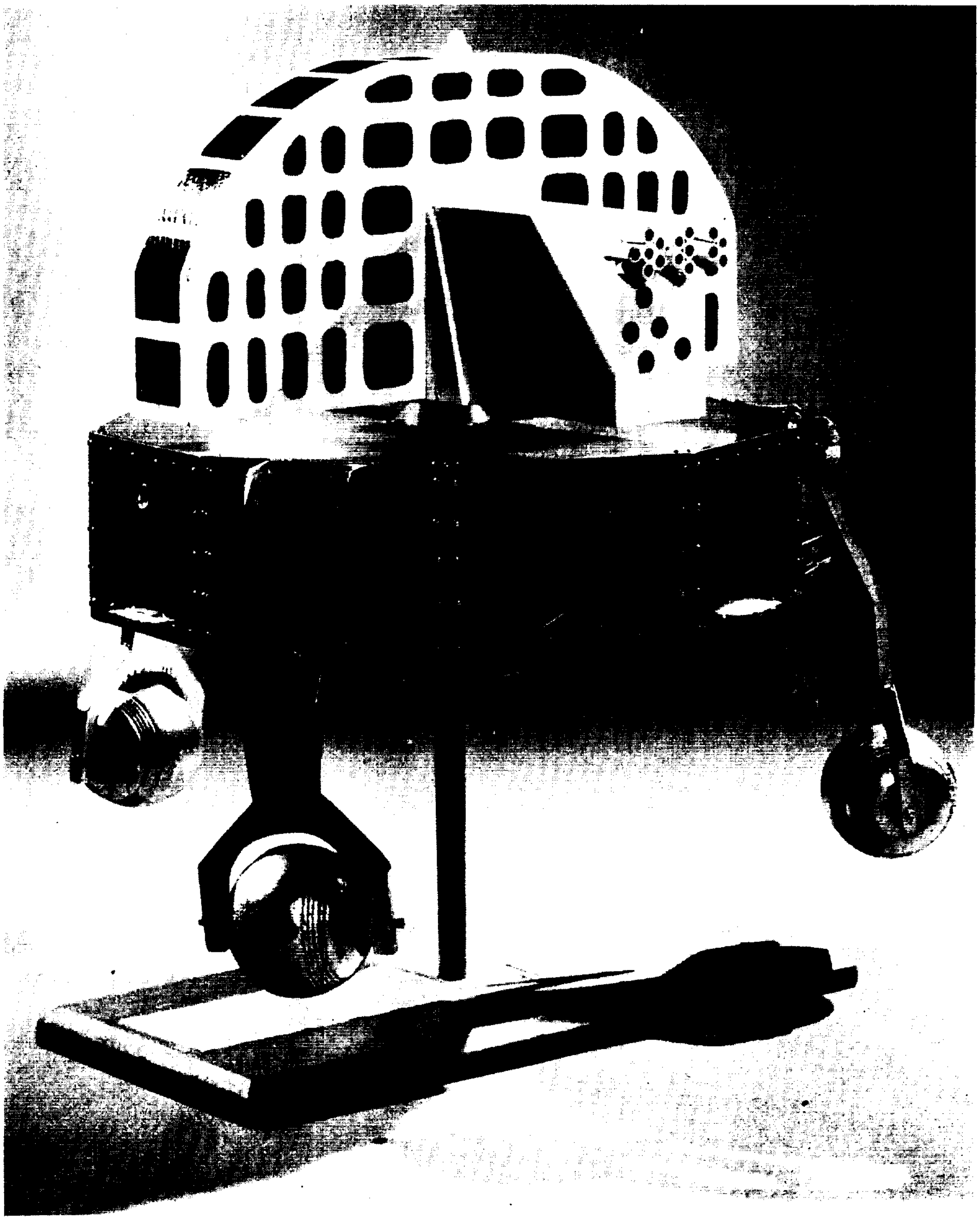
Continuous monitoring of the X-ray flux on the sun is very important because of the speed of its flares. Most of the X-rays occur in the earliest phase of the flare and much of the phenomena of interest were missed by the earlier method of rocket probes because of the time involved.

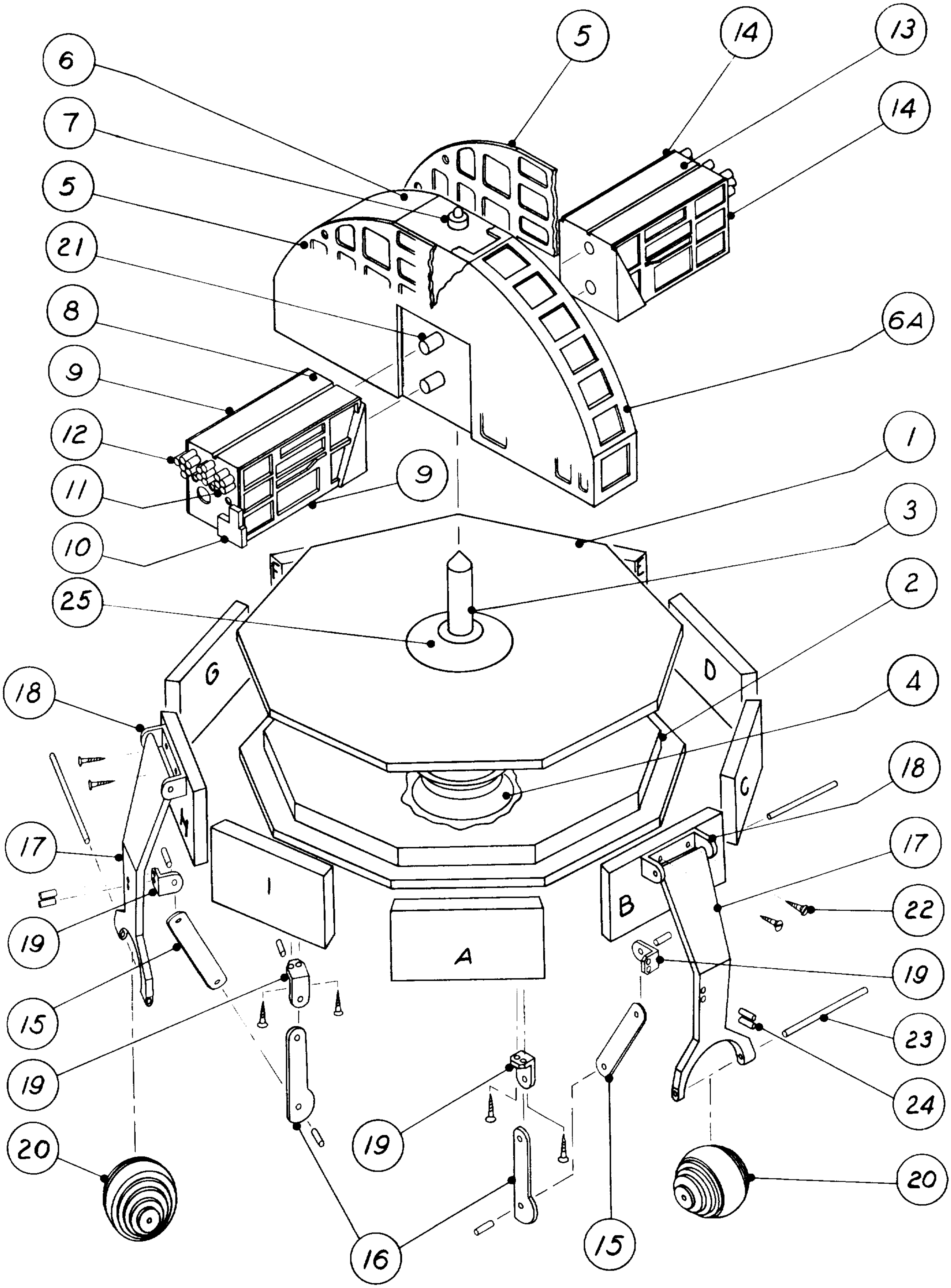
OSO-I was designed to measure the radiation of the entire sun over a broad wave-length region which is inaccessible to measurements by solar observatories on earth. Other more complex orbiting observatories are planned for the future.

With the success of OSO-I we entered a new phase of complex spacecrafts capable of precise orientation over long periods of time.

Thus, we can surpass the old astronomer's dream by placing the telescopes higher than the highest mountain.

O. S. O.





5
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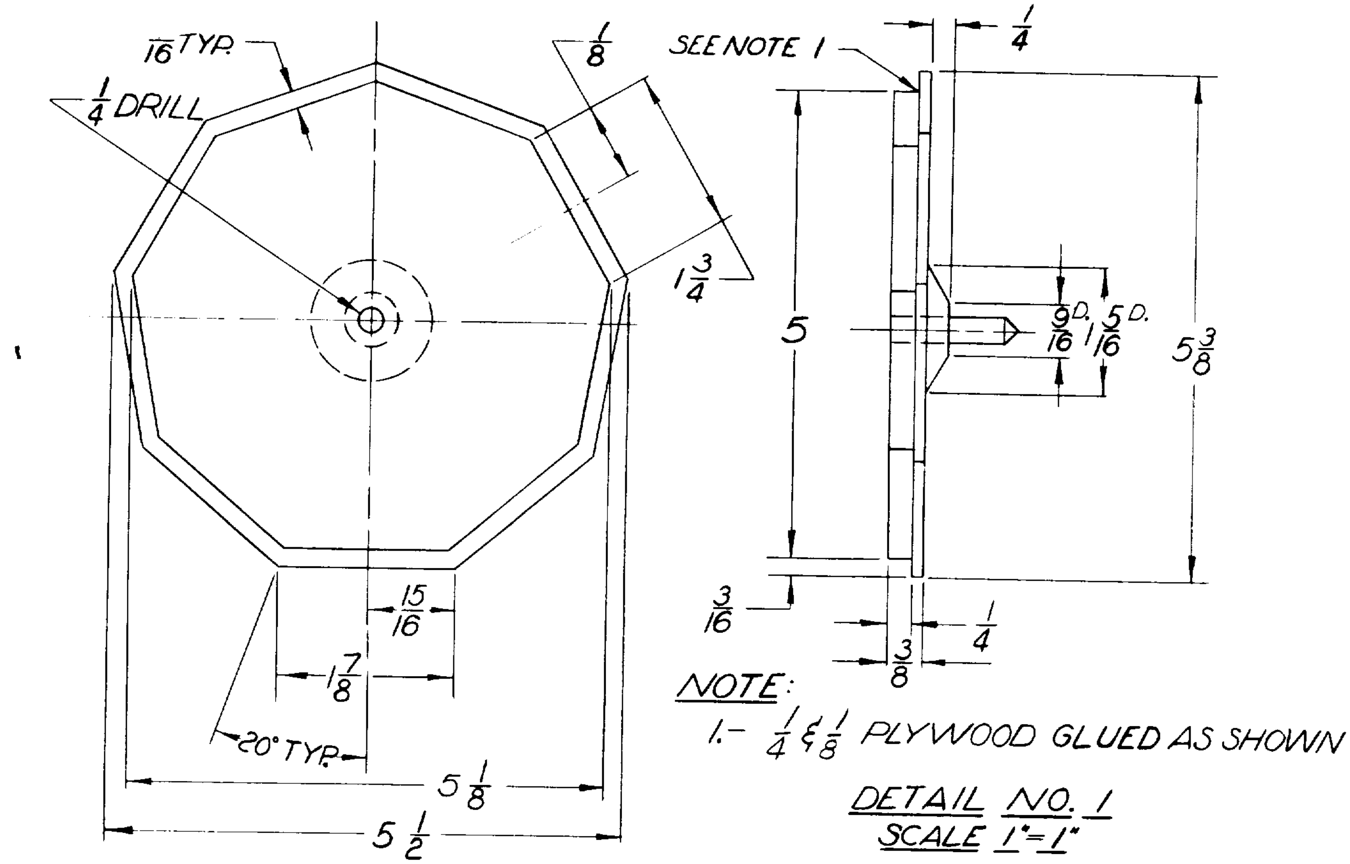
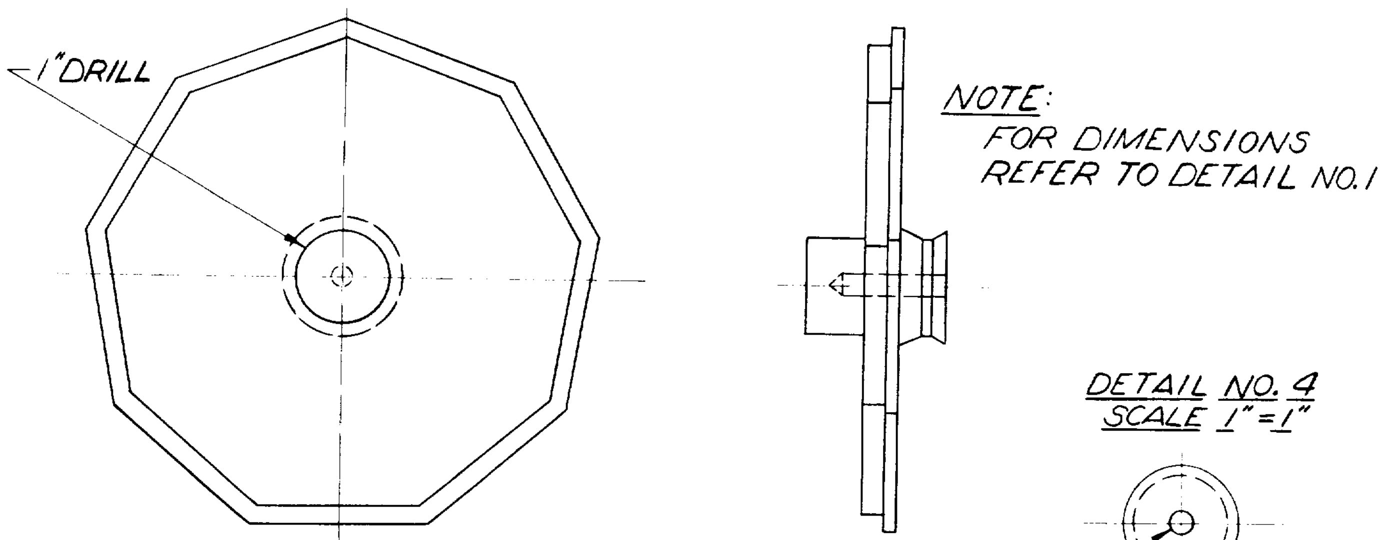
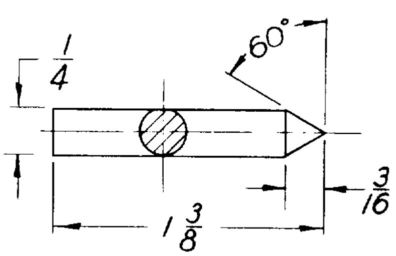



DETAIL NO. 1
SCALE 1"=1"

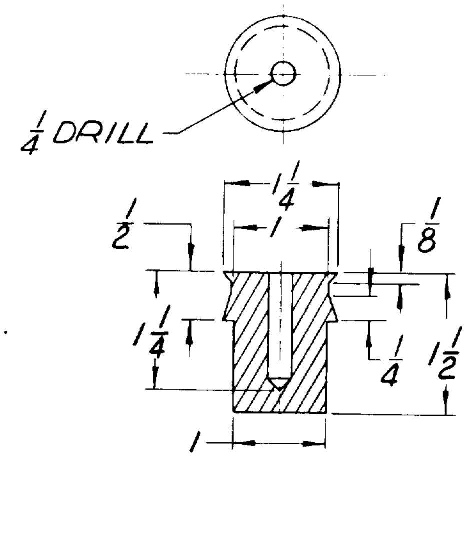


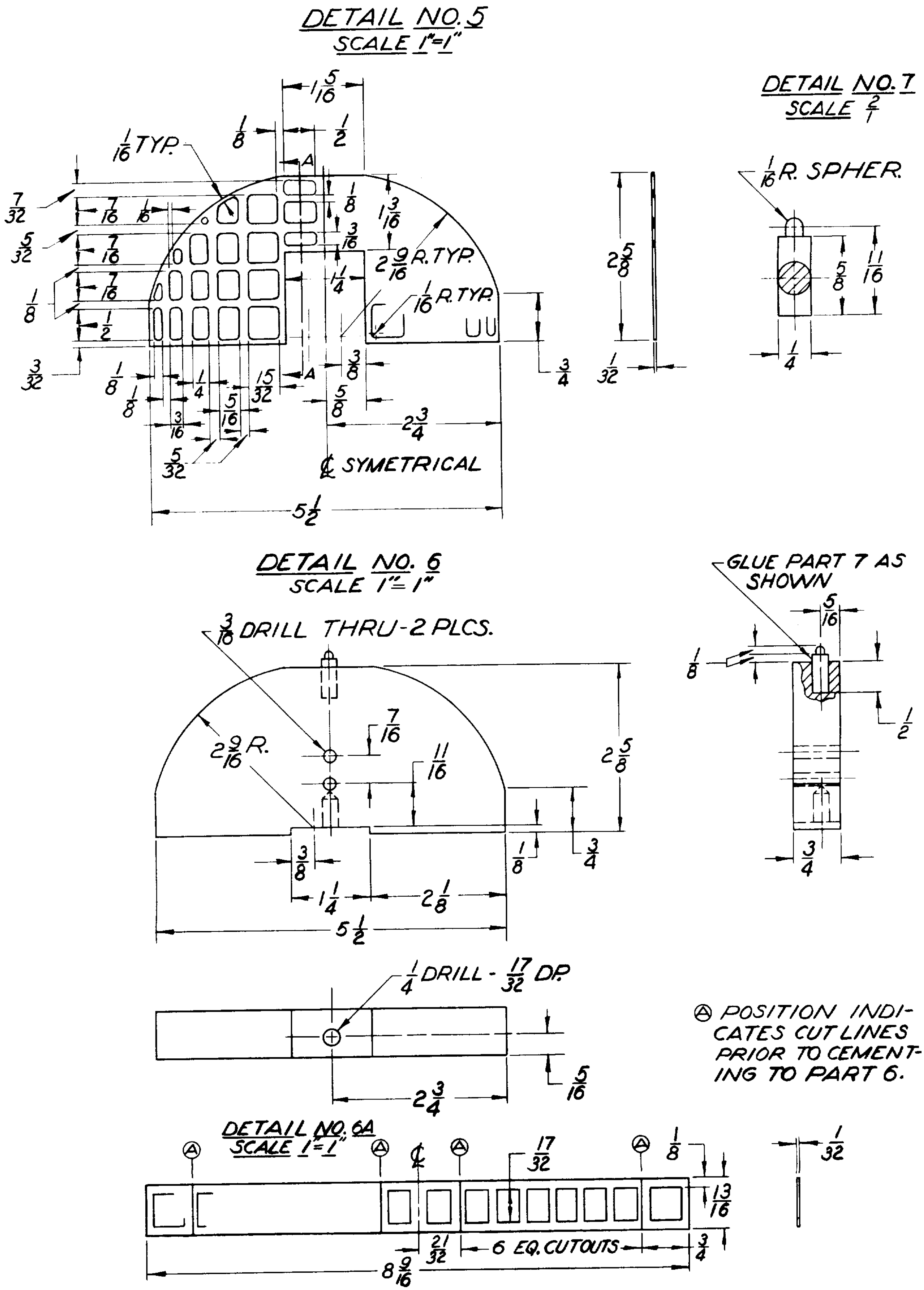

DETAIL NO. 2
SCALE 1"=1"

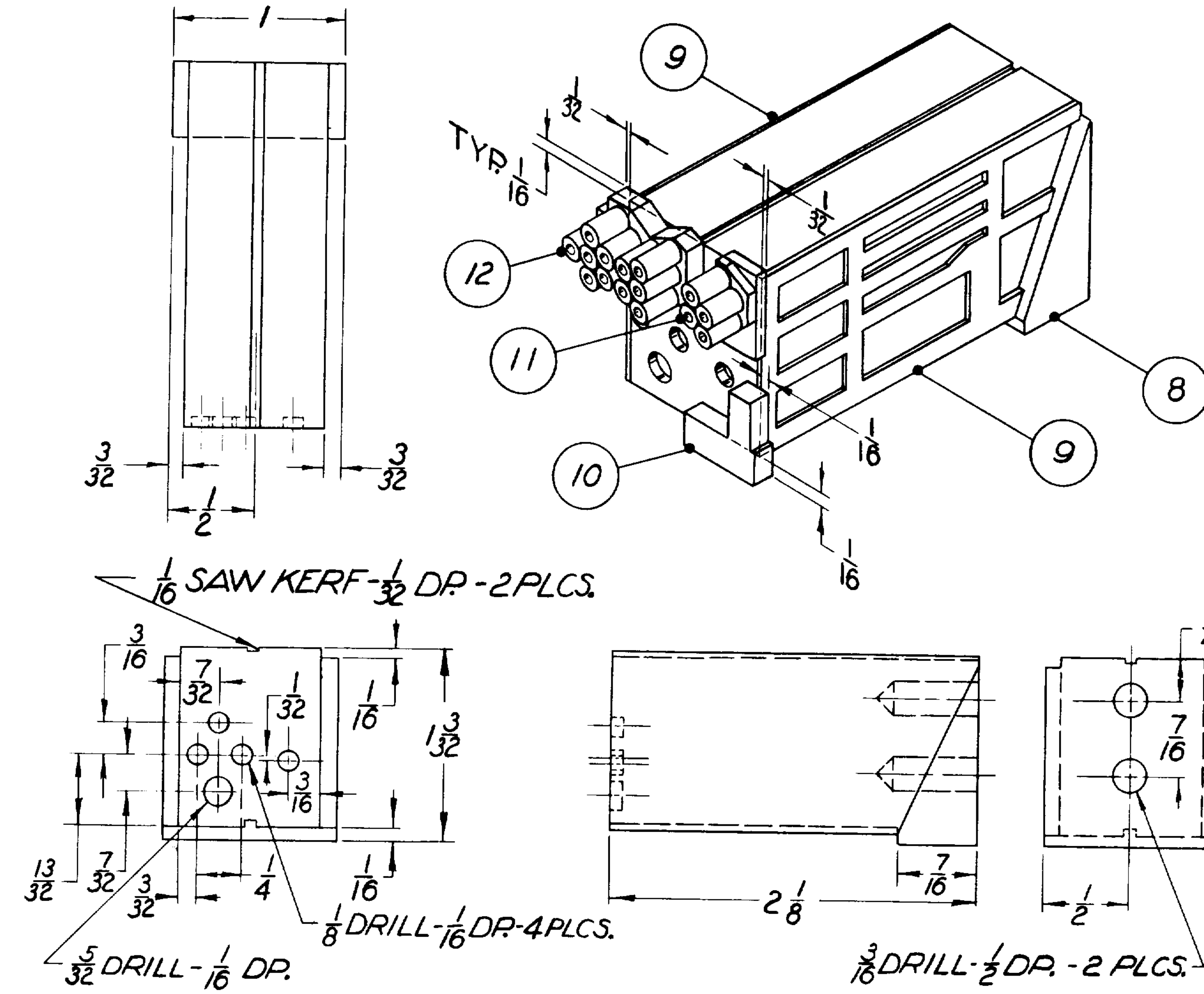



DETAIL NO. 3
SCALE 2/1

DETAIL NO. 4
SCALE 1"=1"



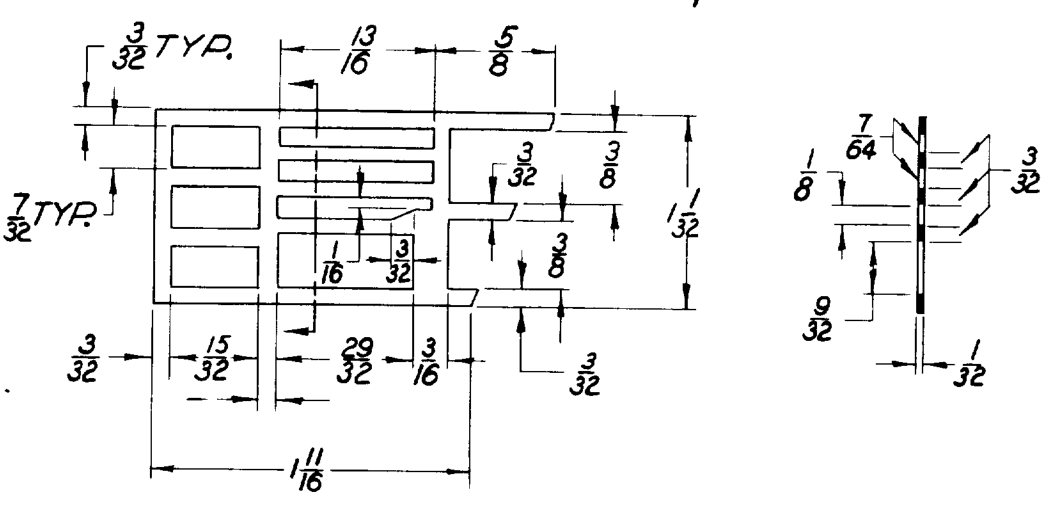

DETAIL NO. 5
SCALE 1"=1"
1/16 TYP.
2 9/16 R. TYP.
1/16 R. TYP.
℄ SYMETRICAL
DETAIL NO. 7
SCALE 2/1
1/16 R. SPHER.
DETAIL NO. 6
SCALE 1"= 1"
3/16 DRILL THRU-2 PLCS.
2 9/16 R.
GLUE PART 7 AS SHOWN
1/4 DRILL - 17/32 DP.
Ⓐ POSITION INDICATES CUT LINES PRIOR TO CEMENTING TO PART 6.
DETAIL NO. 6A
SCALE 1"=1"
6 EQ. CUTOUTS

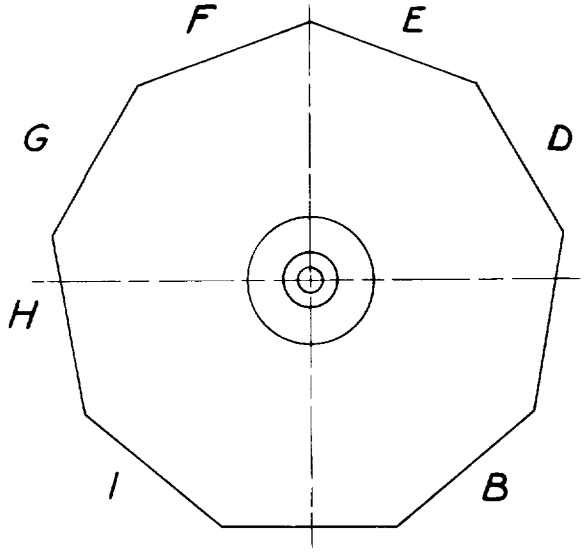



DETAIL NO. 8
SCALE 2/1

NOTE:
PARTS 9, 10, 11 & 12 TO BE GLUED TO PART 8 AS SHOWN ABOVE.

DETAIL NO. 9
SCALE 2/1

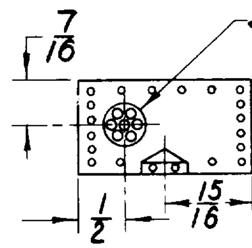




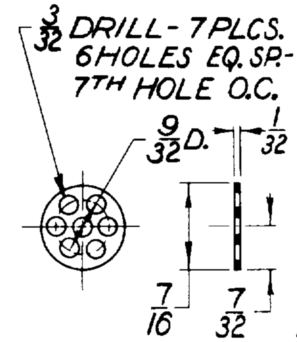

SIDE A
(REF. FRONT)

NOTES:
1.- RIVETS TO BE ESCUTCHEON PINS OR STRAIGHT PINS-CUT SHANK.
2.- PAINT ALL PARTS SILVER-EX. VIEW "A" SIDE C - TO BE BLACK.

## DETAILS - SIDE C

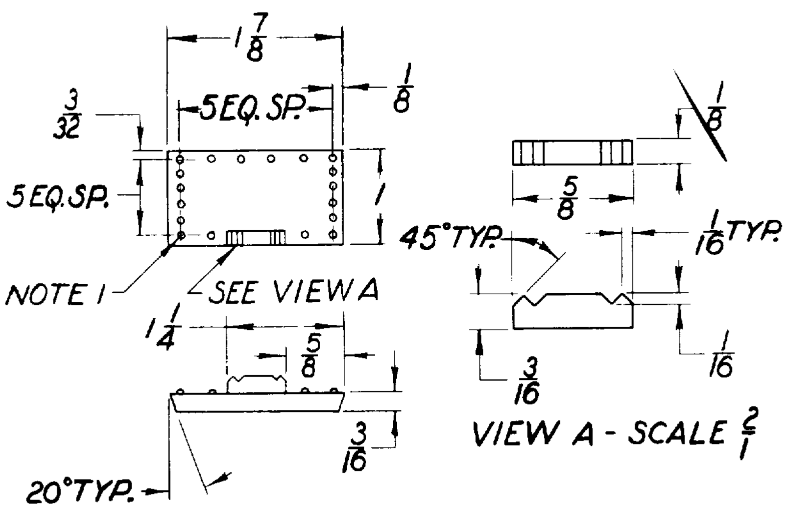



NOTE:
FOR OTHER DIMENSIONS - SEE DETAILS SIDES A & F.



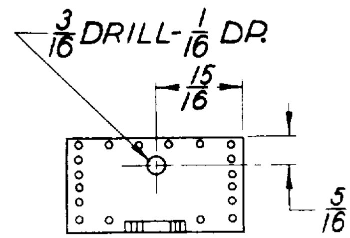

VIEW A - SCALE 2/1

## DETAILS - SIDE A & G



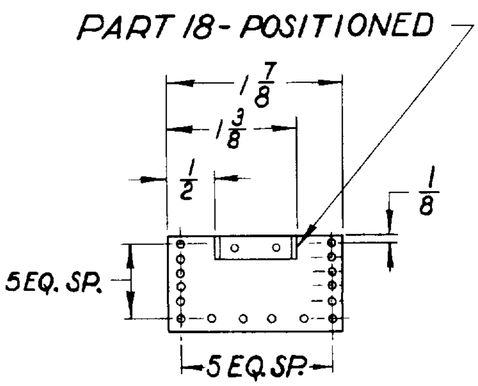

VIEW A - SCALE 2/1

## DETAILS - SIDE D



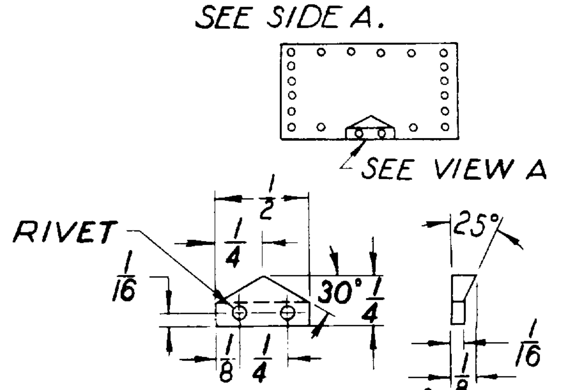

NOTE:
FOR OTHER DIMENSIONS SEE SIDE A.

## DETAILS - SIDES B, E & H



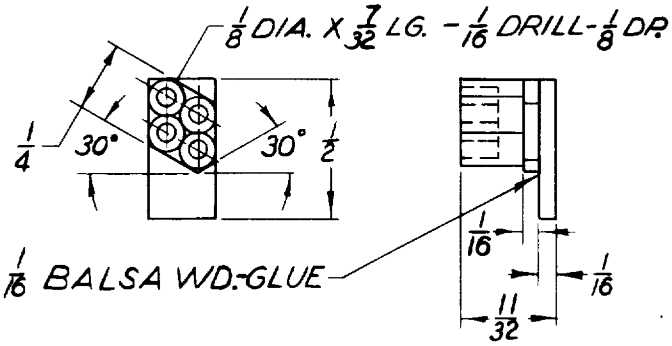

## DETAILS - SIDE F

NOTE:
FOR OTHER DIMENSIONS SEE SIDE A.

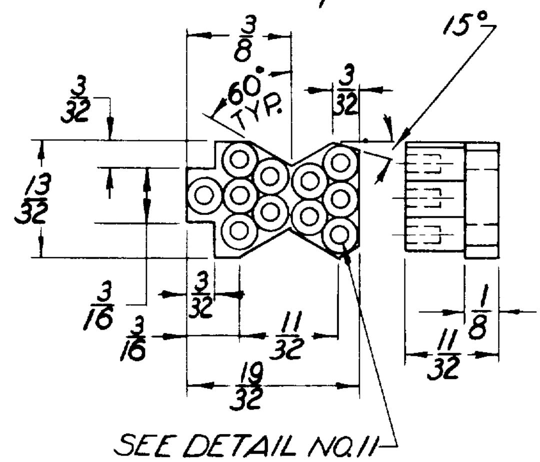


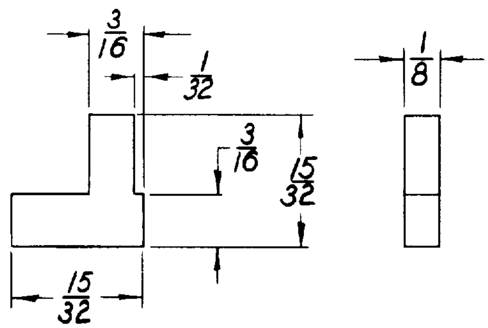

VIEW A - SCALE 2/1

DETAIL NO. 11
SCALE 3/1



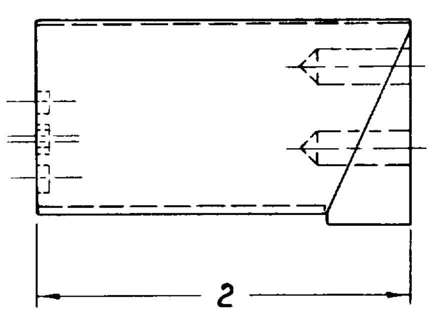

DETAIL NO. 12
SCALE 3/1



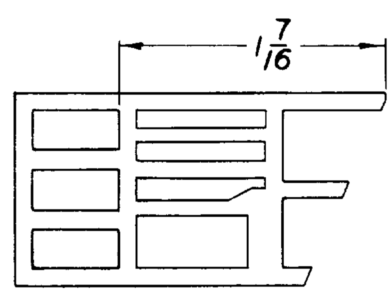

DETAIL NO. 10
SCALE 3/1

DETAIL NO. 13
SCALE 2/1

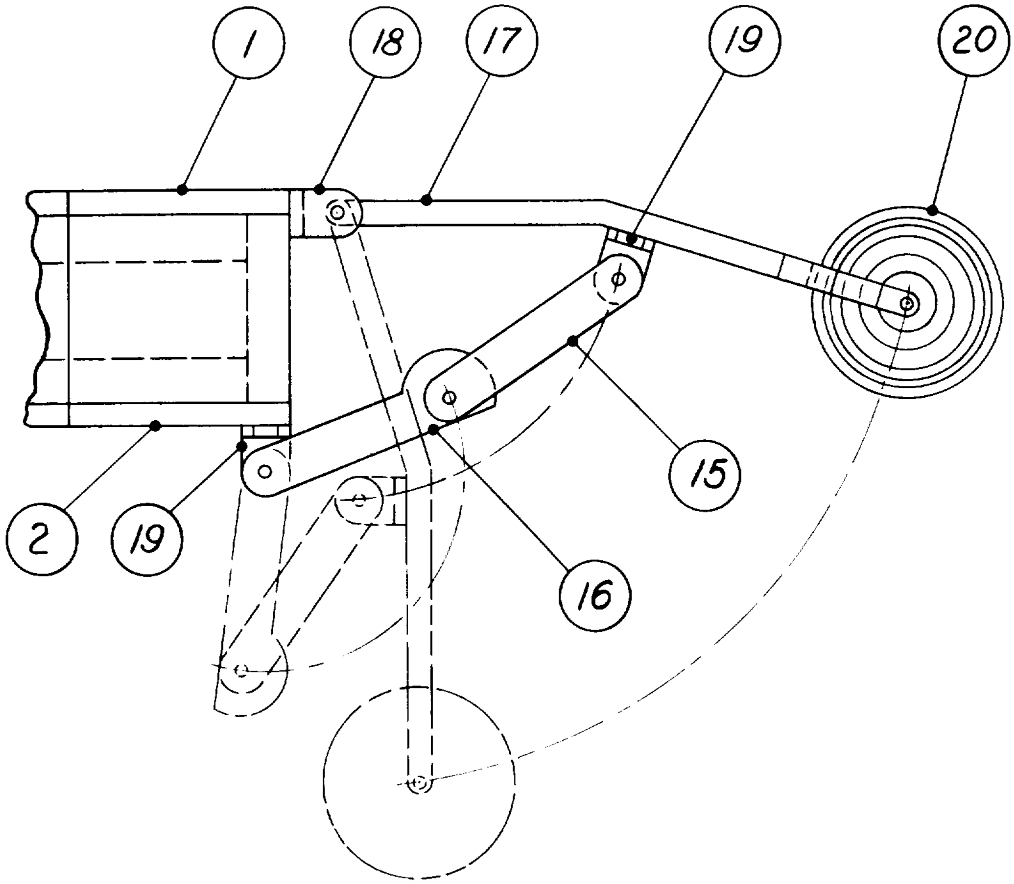



NOTE:
FOR ALL OTHER DIMENSIONS
SEE DETAIL NO. 8.

DETAIL NO. 14
SCALE 2/1




NOTE:
FOR ALL OTHER DIMENSIONS
SEE DETAIL NO. 9.




NOTES:

1.- ATTACH BRACKETS 18 & 19 TO PARTS 1 & 2 WITH NO. 0 F.H. WD. SCR. - $\frac{3}{8}$ LG.

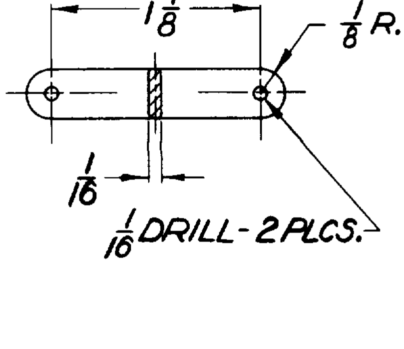
2.- ATTACH BRACKET 19 TO PART 17 WITH $\frac{1}{16}$" RIVETS (BRAZING ROD).

3.- LINKAGE ARMS NOS. 15 & 16 RIVETED TOGETHER & TO BRACKETS 19 WITH $\frac{1}{16}$" RIVETS (BRAZING ROD).

4.- STABILIZING ARMS (17) TO BE ATTACHED TO THE NONAGON SIDES B, E & H.

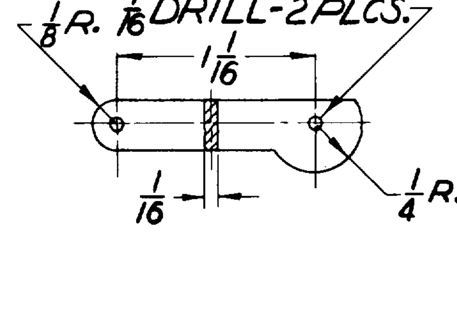
DETAIL NO. 15

SCALE $\frac{2}{1}$

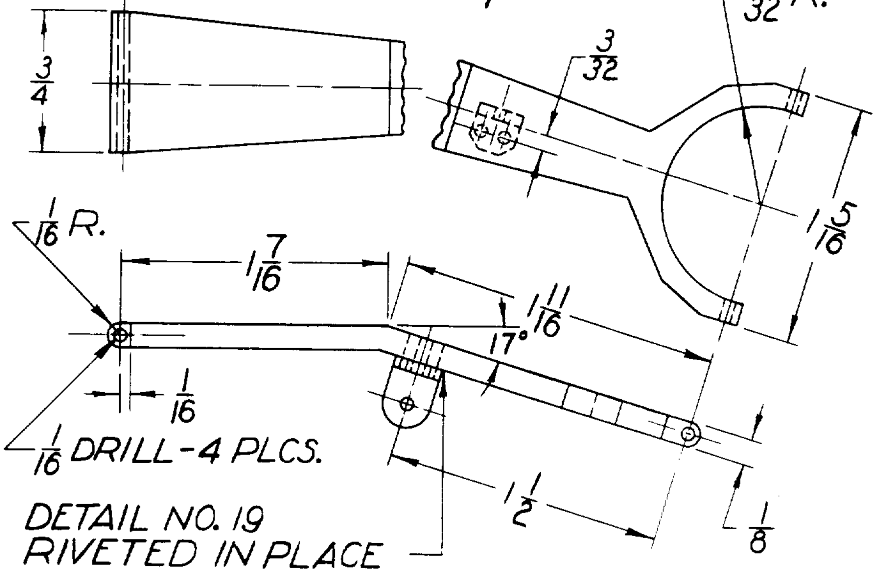


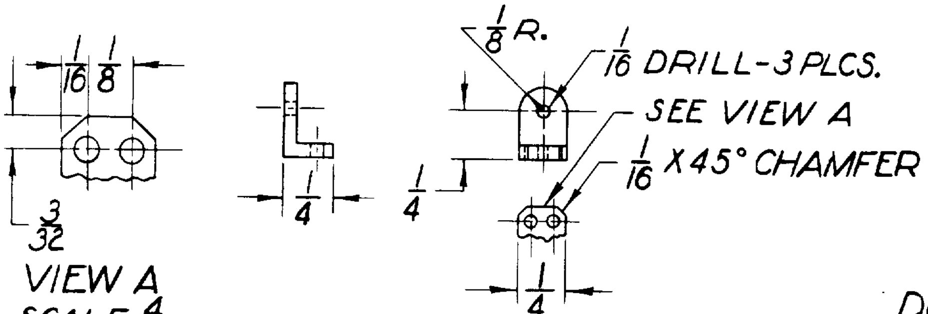

DETAIL NO. 16

SCALE $\frac{2}{1}$



DETAIL NO. 17
SCALE $\frac{2}{1}$

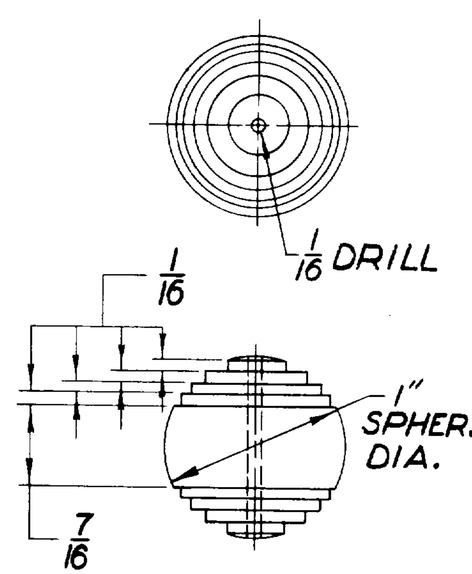


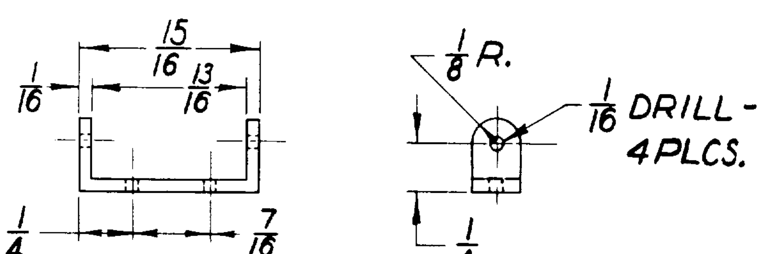




VIEW A
SCALE $\frac{4}{1}$

DETAIL NO. 19
SCALE $\frac{2}{1}$

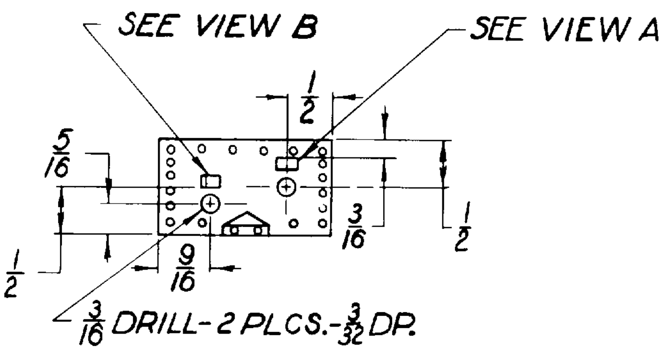
DETAIL NO. 20
SCALE $\frac{2}{1}$

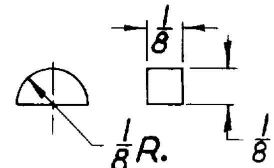


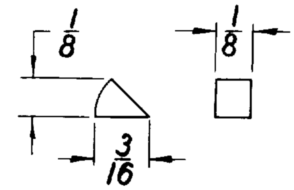

DETAIL NO. 18
SCALE $\frac{2}{1}$

## DETAILS - SIDE 1



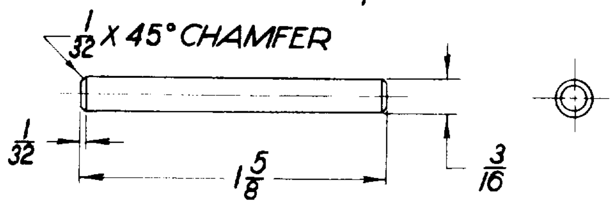

VIEW A - SCALE $\frac{3}{1}$



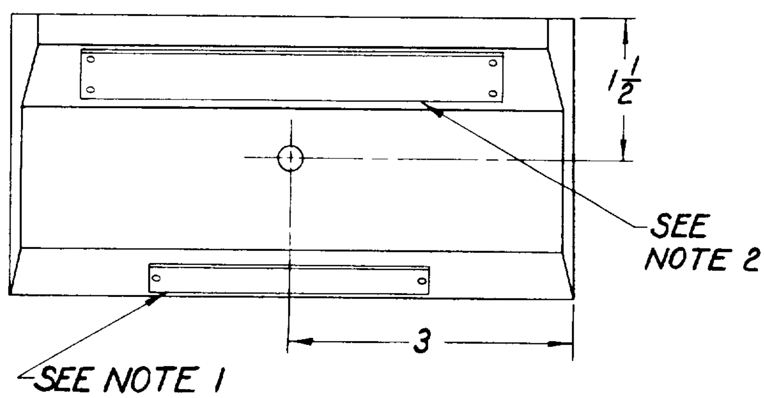

VIEW B - SCALE $\frac{3}{1}$

NOTE:
FOR OTHER DIMENSIONS - SEE SIDES A & F.

## DETAIL NO. 21
SCALE - $\frac{2}{1}$

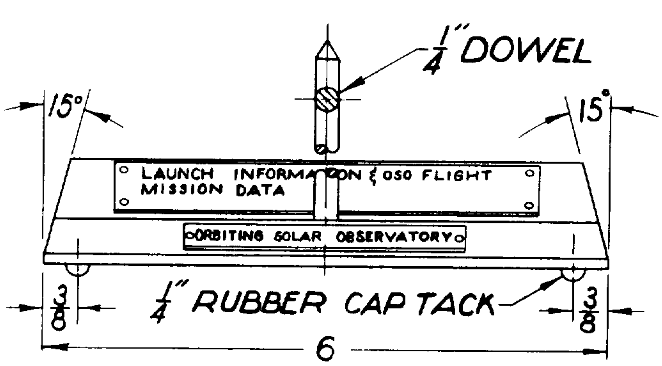


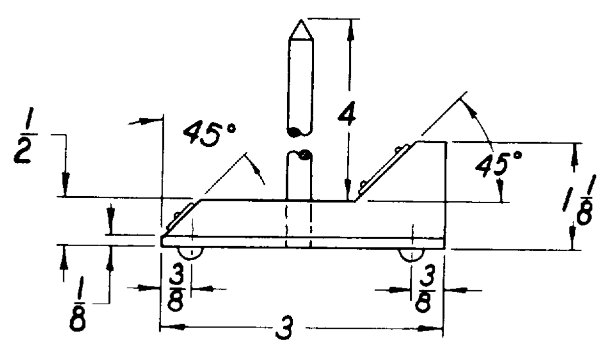

## O.S.O. MODEL STAND
SCALE 1" = 1"




NOTES:

1. - $\frac{3}{8}$" X 3" BRASS PLATE - STAMP WITH $\frac{1}{8}$" LETTERS.
2. - COVER TYPED INFORMATION WITH $\frac{1}{16}$" X $\frac{3}{4}$" X $4\frac{1}{2}$" CLEAR PLASTIC.



RECOMMENDED MATERIALS FOR CONSTRUCTION

ORBITING SOLAR OBSERVATORY

| PART NUMBER | NUMBER REQUIRED | RECOMMENDED MATERIAL | COLOR |
|---|---|---|---|
| 1 | Two | Plywood - 1/8" | Silver |
| 2 | Two | Plywood - 1/4" | Natural |
| 3 | One | Wood - maple | Silver |
| 4 | One | Wood - maple | Silver |
| 5 | Two | Wood - balsa | Silver |
| 6 | One | Wood - pine | Black |
| 6A | One | Wood - balsa | Silver |
| 7 | One | Wood - maple | Black |
| 8 | One | Wood - pine | Black |
| 9 | Two | Wood - balsa | Silver |
| 10 | Two | Wood - maple | Silver |
| 11 | Two | Wood - maple | Silver |
| 12 | Two | Wood - maple | Silver |
| 13 | One | Wood - pine | Black |
| 14 | Two | Wood - balsa | Silver |
| 15 | Three | Band iron | Silver |
| 16 | Three | Band iron | Silver |
| 17 | Three | Band iron | Silver |
| 18 | Three | Band iron | Silver |
| 19 | Six | Band iron | Silver |

RECOMMENDED MATERIALS FOR CONSTRUCTION

ORBITING SOLAR OBSERVATORY

| PART NUMBER | NUMBER REQUIRED | RECOMMENDED MATERIAL | COLOR |
|---|---|---|---|
| 20 | Three | Wood - maple | Silver |
| 21 | Two | Dowel - rod | Natural |
| 22 | Twelve | Metal wood screws | Silver |
| 23 | Three | Metal brazing rod | Natural |
| 24 | Fifteen | Metal brazing rod | Natural |
| 25 | One | Wood - maple | Silver |
| A-I | Nine | Wood - pine | Silver |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

ORBITING SOLAR OBSERVATORY

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 1 | Wood - 1/8" plywood | Layout and cut a nonagon to specified dimensions | | |
| 2 | Wood - 1/4" plywood | Layout and cut a nonagon to specified dimensions | | |
| 4 | Wood - maple | Turn on lathe to specified dimensions and drill as specified | | |
| A&G )<br>B,E,H)<br>C )<br>D )<br>F )<br>I ) | Wood - pine<br><br>Use escutcheon pins for surface effect | Fabricate parts to specified dimensions and details | Finish sand all surfaces | Subassemble as indicated on detailed drawings |
| 25 | Wood - maple | Turn on lathe as specified on detail no. 1 and drill to accommodate part no. 3 | Finish sand all surfaces | |
| 3 | Dowel - rod | Cut and shape to specified dimensions | | Subassemple parts 1,2,3,4,25 and A through I |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

ORBITING SOLAR OBSERVATORY

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 15,16, 17,18, 19 | Band iron | Cut and shape to specified dimensions | | Subassemble parts 15,16,17,18 and 19 as noted and attach one each to parts B,E and H with part no. 22 |
| 20 | Wood - maple | Turn on lathe to specified dimensions and drill for part no. 23 | Finish sand all surfaces | |
| 23 | Brass rod | Cut to specified length | Polish | Assemble part no.20 to part no.17 using part no.23 |
| | | | Paint assembled parts 1,3,4,15, 16,17,18,19,20, 23,25 and A through I silver | |
| 6 | Wood - pine | Cut and shape to specified dimensions | | |

RECOMMENDED PROCEDURE FOR CONSTRUCION

ORBITING SOLAR OBSERVATORY

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 7 | Dowel - rod | Cut and shape to specified dimensions | Finish sand all surfaces | Assemble to part no.6 as indicated |
| 6A | Wood - balsa | Cut and fabricate to specified dimensions | | Glue to part no. 6 as indicated |
| 5 | Wood - balsa | Cut and fabricate to specified dimensions | | Glue to part no. 6 as indicated |
| 8 | Wood - pine | Cut and fabricate to specified dimensions | | |
| 9 | Wood - balsa | Cut and fabricate to specified dimensions | | |
| 10 | Wood - hard | Fabricate to specified dimensions | | |
| 11&12 | Wood - Dowel-rod and balsa | Fabricate to specified dimensions | Finish sand all surfaces | Glue parts 9,10,11 & 12 to part no. 8 as indicated |
| 13 | Wood - pine | Cut and fabricate to specified dimensions | | |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

ORBITING SOLAR OBSERVATORY

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 14 | Wood - balsa | Cut and fabricate to specified dimensions | | Glue parts 10,11, 12 and 14 to part no. 13 as indicated on detail no.8 |
| | | | Finish sand all surfaces | |
| | | | Paint assembled part nos. 5,6A, 9,10,11,12 and 14 silver | |
| | | | Paint assembled part nos. 6,7,8 and 13 black | |
| Model Stand | Wood - walnut | Recommended construction is indicated on detail sheet | Natural rubbed oil finish | |

# R E L A Y

Around the world in 80 days --- around the world in 80 hours ---- around the world in 80 minutes ---- around the world in 80 seconds. In this rapidly shrinking time-world, instantaneous global communication is becoming a necessity.

Studies indicate that the conventional limited-capacity overseas communications facilities will not be adequate for the expected increase in traffic. In 1960 there were almost four million overseas telephone calls. Reliable estimates indicate a five-fold increase in the next decade. Such an increase will overtax the current as well as the planned underseas cable and high frequency radio facilities. There is little doubt that transoceanic satellite communications will be needed to supplement these facilities.

Economic studies which have already been undertaken indicate that the comsats (communications satellite) can provide services comparable to those of the undersea cable at a lower cost per channel of capacity. Also it may well be the only means of providing high quality communication to remote, less-developed areas.

The comsat era began in 1958 when the famous Christmas message from the president was transmitted to the world by the Project Score satellite. It was followed in 1960 by Echo I, the first passive communications satellite; and Courier, the "delayed repeater" satellite. Telstar was boosted into orbit in July 1962, Relay in December 1962, and Syncom in February 1963.

These satellites represent the beginning stages of the investigation and exploitation of the three basic techniques applicable to operational communication systems. Active satellites in low and medium altitude orbits, active satellites in 24-hour synchronous orbits, and passive reflector satellites in low orbits are the techniques under study.

Echo I, a 100-foot metallized balloon, performed many successful transcontinental and transoceanic experiments but a radio mirror such as this passive reflector satellite merely reflects signals. Because they do not amplify signals, the reflecting area of the satellites must be large and the ground stations must be large and complex.

The active satellites, which carry receivers and transmitters for amplifying and retransmitting the received signals, hold great promise for the future. The dramatic demonstrations of trans-Atlantic television which have taken place via Telstar and Relay have proved that satellites of this type are capable of providing excellent intercontinental communications. Because it is a powered amplifying repeater, the active communications satellite can be quite small. It is also possible to use less sensitive ground transmitting equipment.

The Relay is an interesting example of an experimental satellite of the intermediate-altitude type. The spacecraft weighs 172 pounds, is 32 inches high and has a maximum breadth of 29 inches. From one end extends the 18-inch ringlike antenna structure which handles both the transmission and the reception of communication signals. Its eight sides contain more than 8,000 solar cells. The whiplike antennas at the broad end of the craft are part of the systems for turning Relay experiments on and off. It also acquires and sends to Earth data on component behavior and on radiation in space.

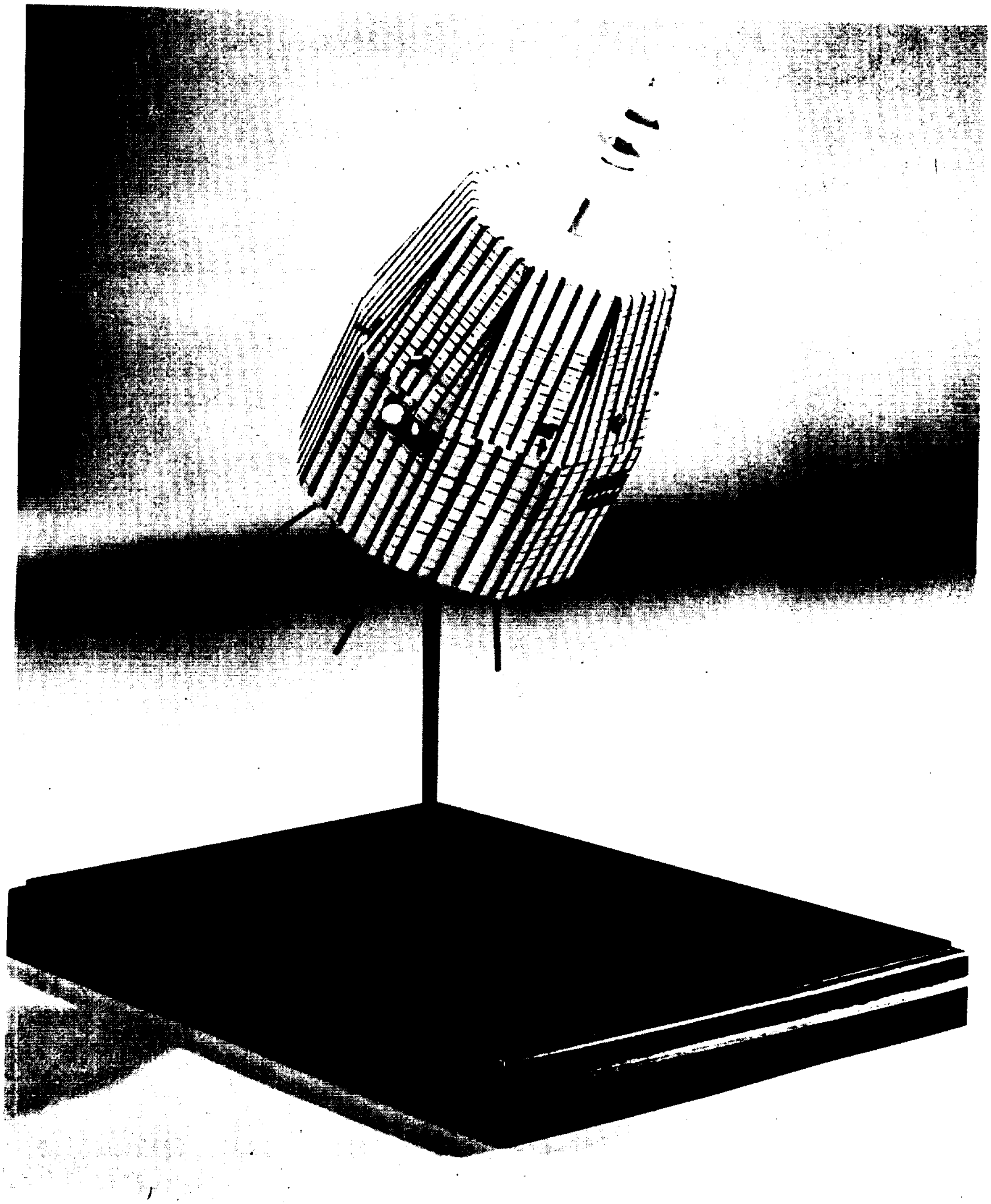
After successful injection into a 819/4612 mile orbit by a Delta vehicle on December 13, 1962, an abnormal power drain initially prevented tests. Failure of the voltage regulator was found to be the cause and the use of the redundant transponder permitted experiments beginning January 3, 1963. On January 9, a television program from the National Gallery of Art in Washington D.C. was successfully telecast to stations in France and Great Britain. Since then many other engineering tests and demonstrations have been performed using this satellite.

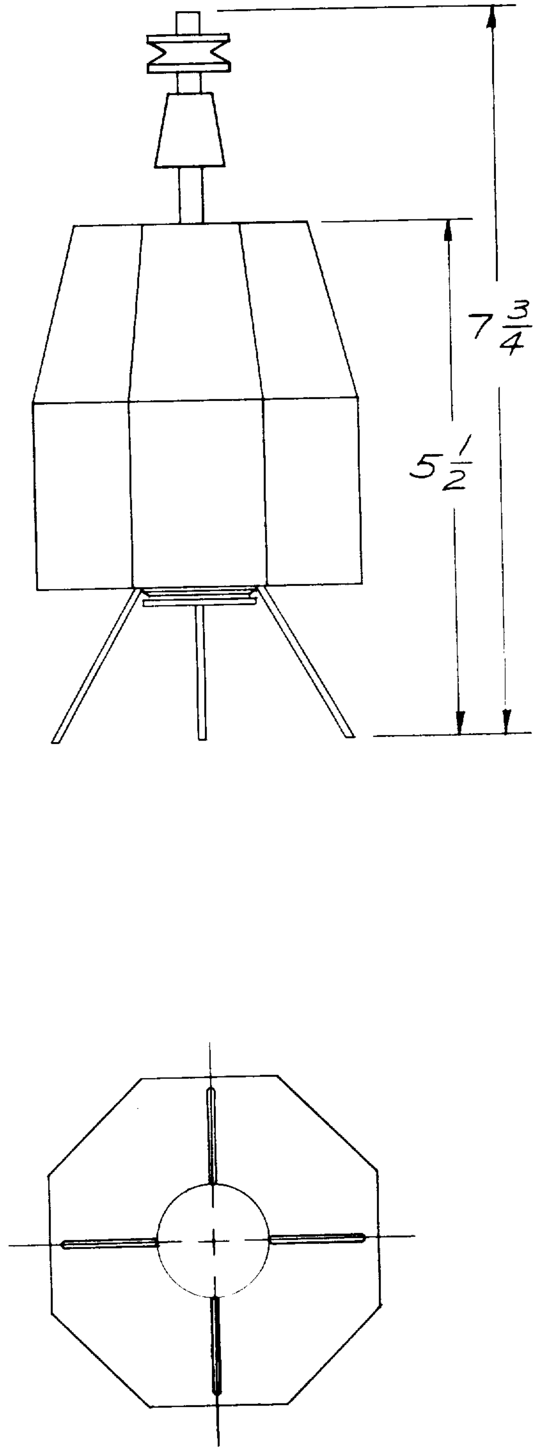
The usefulness of the communications satellite and its importance in world-wide communications are beyond question. The involvement of the world in the peaceful use of these satellites is another important aspect of the program. The extent to which other countries are willing to fund ground facilities for experimental purposes illustrates the broad international interest in the communications satellites. Stations in the United States, Brazil, France, England, Italy and Germany are cooperating in the Relay experiments. The station in Japan will be operational in 1964. Interest in providing ground stations has been indicated by several other countries including the Scandinavian countries, Canada and India.

Satellites thousands of miles above Earth's surface can provide not only efficient communication for the entire world but can link all the countries in the peaceful use of space. In the words of the late President Kennedy: "There is no more important field at the present time than communications and we must grasp the advantages presented to us by the communications satellites to use this medium wisely and effectively to insure greater understanding among the people of the world."*

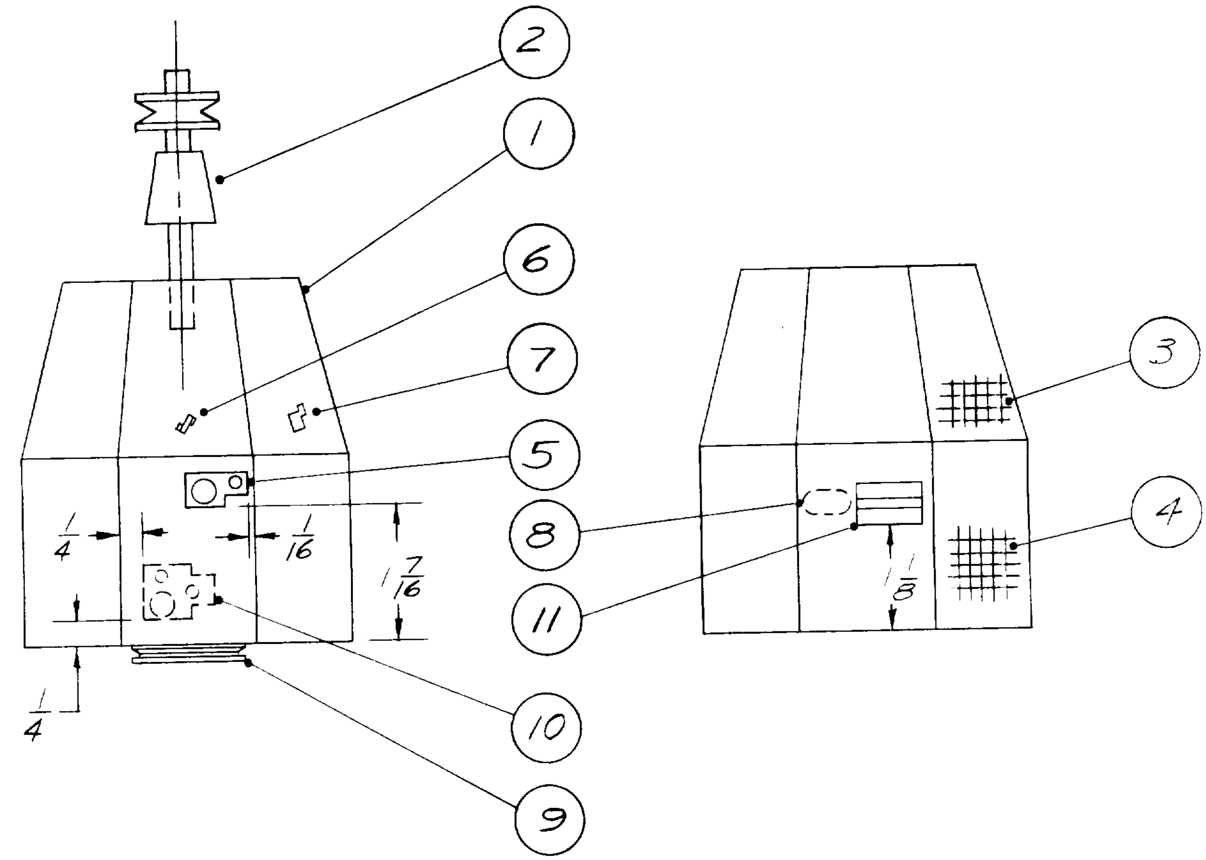
*Public statement by John F. Kennedy in 1962.

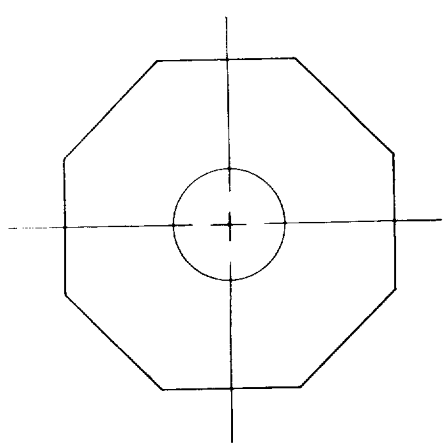
RELAY



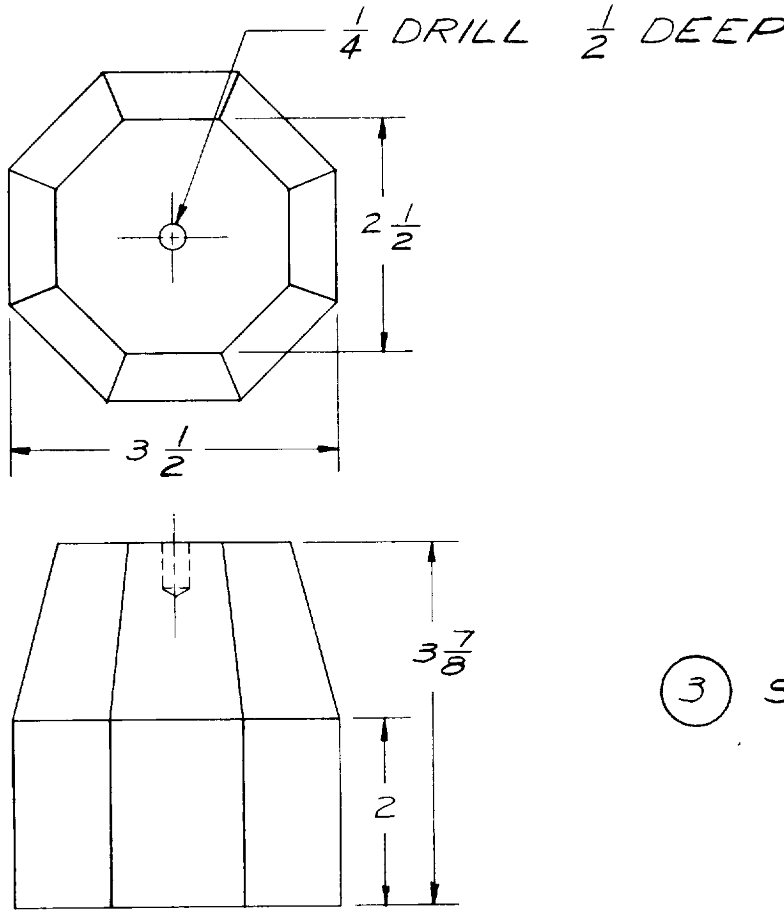



1-A RELAY

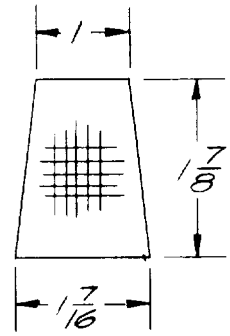


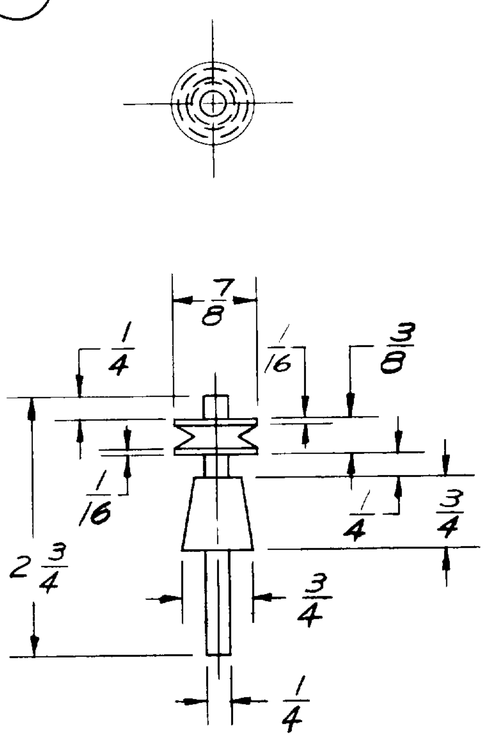
(2-A) RELAY



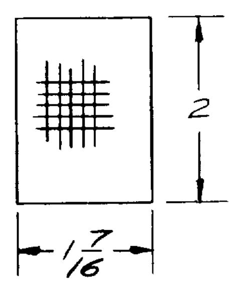

1 BASE 1-REQD



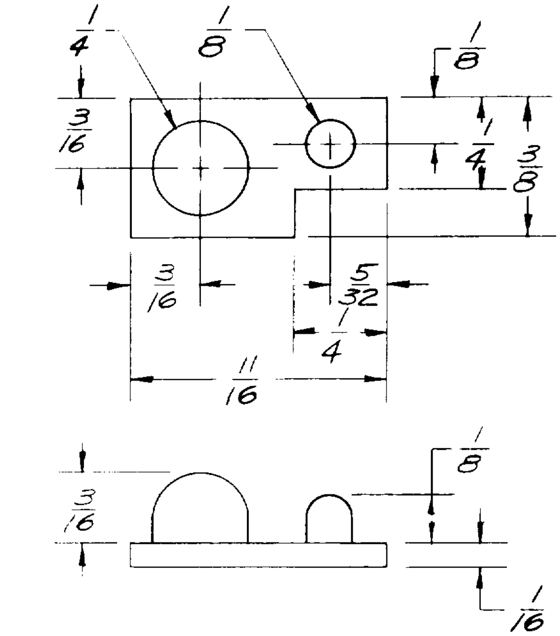

3 SOLAR CELL
8-REQD.



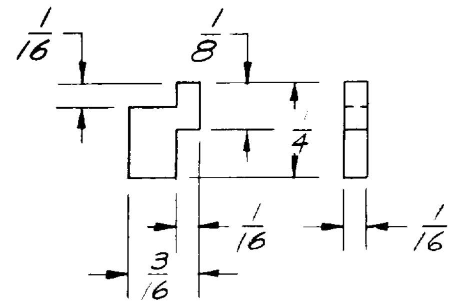

2 1-REQD



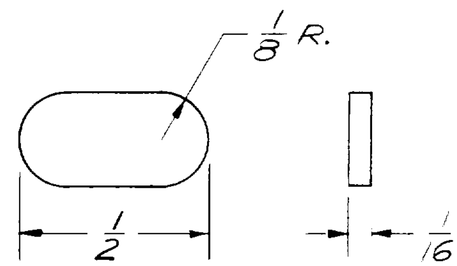

4 SOLAR CELL
8-REQD.




(5) 1-REQD 4X




(7) 4-REQD 4X

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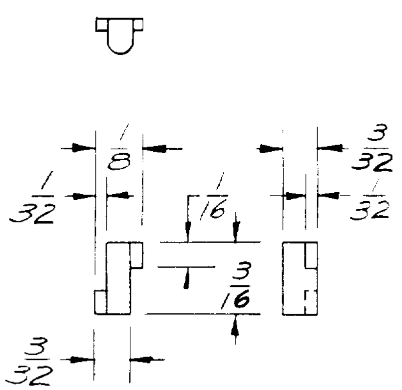


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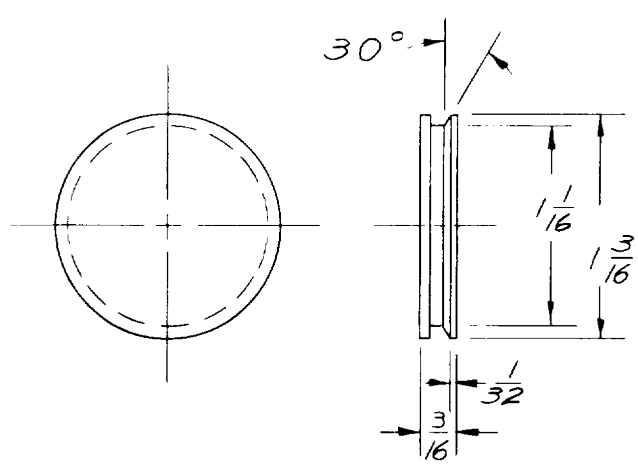
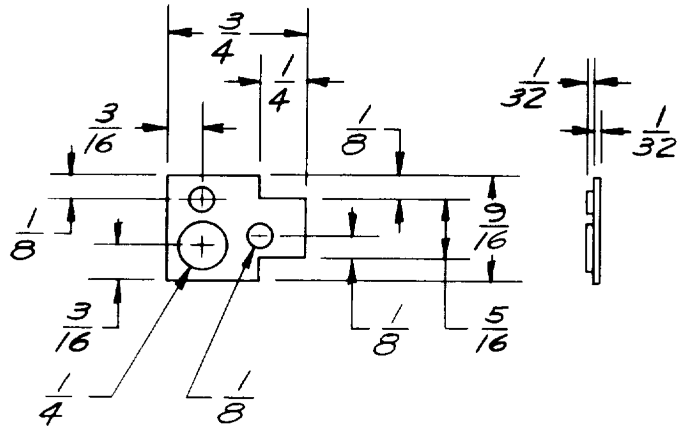
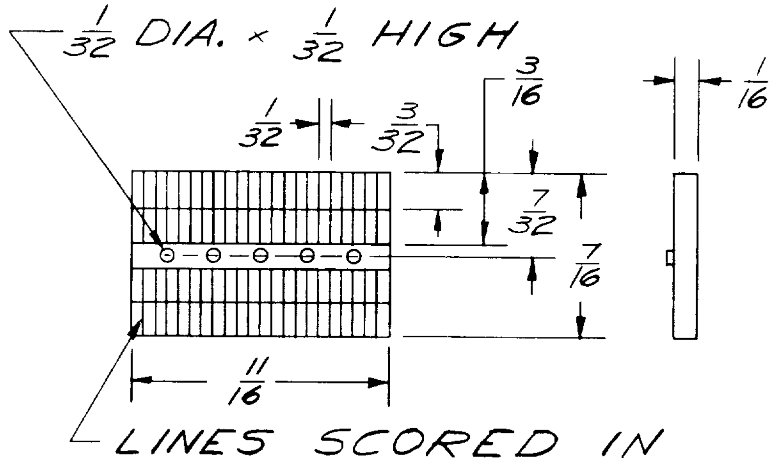



(9) 1-REQD 4X




(10) 1-REQD 2X




(11) 1-REQD 4X

RECOMMENDED MATERIALS FOR CONSTRUCTION

RELAY

| PART NUMBER | NUMBER REQUIRED | RECOMMENDED MATERIAL | COLOR |
|---|---|---|---|
| 1 | One | Wood - pine | White |
| 2 | One | Wood - maple | White |
| 3&4 | Eight each | - | Black lines on part no. 1 to indicate solar cell surfaces |
| 5 | One | Wood - balsa | Blue base |
| 6 | Four | Wood - balsa | Gold |
| 7 | Four | Wood - balsa | Blue |
| 8 | One | Plastic | Blue |
| 9 | One | Wood - maple | Silver |
| 10 | One | Wood - balsa | Blue base and white projections |
| 11 | One | Wood - balsa | Blue base and white projection |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

RELAY

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIOUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 1 | Wood - pine | Construct octagon body to specified dimensions. Drill as per detailed drawing | Finish sand all surfaces. Paint white | |
| | | Layout and mark solar cells on all surfaces as indicated on detail nos. 3 and 4 | Marks to be made with India ink | |
| 2 | Wood (maple), plastic or brass | Turn on lathe to specified dimensions | Finish sand all surfaces and paint white | Assemble part no. 2 to part no. 1 using epoxy resin |
| 5 | Balsa wood, fiber or plastic with dowel rod for the round parts | Construct to specified dimensions | Finish sand all surfaces | |
| 6 | Balsa wood, fiber or plastic | Construct to specified dimensions | Finish sand all surfaces | |
| 7 | Balsa wood, fiber or plastic | Construct to specified dimensions | Finish sand all surfaces | |
| 8 | Balsa wood, fiber or plastic | Construct to specified dimensions | Finish sand all surfaces | |

## RECOMMENDED PROCEDURE FOR CONSTRUCTION

### RELAY

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 9 | Wood (maple) or plastic | Turn on lathe to specified dimensions | Finish sand all surfaces | Assemble part no. 9 to part no. 1 using epoxy resin |
| 10 | Balsa wood and dowel rod | Construct to specified dimensions | Finish sand all surfaces | Assemble parts no. 5,6,7,8,10 and 11 to part no. 1 using epoxy resin |
| 11 | Balsa wood, fiber or plastic | Construct to specified dimensions | Finish sand all surfaces<br>Paint parts no. 5,7,8,10 and 11 blue<br>Paint part no. 6 gold<br>Paint part no. 9 silver<br>Paint projections on parts no. 5,10, and 11 white | |

M A R I N E R

In the beginning there was -------. No one can continue this sentence with absolute certainty because it is like trying to describe one's own birth. He would have to start with present conditions and work backwards in time through areas in which knowledge is still incomplete. Although scientists today know many more facts than those in the past, they must explain much more than the ocean and dry land or sun by day and moon by night. How did the earth begin? How did life begin? Is this the only planet on which life exists?

When we unravel the mysteries of other planets we may gain more understanding of our own. Can some of the answers be provided by man's "morning and evening star"? Venus, hiding in her perpetual cloud, has been the object of much speculation because of her almost identical size to the earth and her similar gravitational field. Is there life on our sister planet, Venus?

A "giant" step was taken on December 14, 1962, when Mariner II flew past Venus at a distance of 21,648 miles, giving man his first relatively close-up observation of earth's closest planetary neighbor. Until the present time, only extremely long-range methods of gathering data have been available with which to study this planet. Analysis of radar echoes and sunlight reflection over a distance of 26 million miles are the techniques which have been used.

The Mariner spacecrafts were built for the purpose of obtaining scientific information on Venus from close range. The first Mariner vanished in flames on July 22, 1962, after 290 seconds of flight. It was deliberately destroyed because it was off course. No more than a misplaced hyphen in the equations fed into a computer was the cause of the failure!

A month later on August 27, Mariner II was boosted by a two-stage Atlas-Agena B rocket on its journey into space. The gleaming spacecraft was five feet in diameter and nine feet eleven inches high. In cruise position with solar paddles and antenna extended, it measured sixteen feet six inches across and eleven inches high. Of its 449 pounds, the scientific equipment for gathering information weighed 40 pounds. The remainder of its weight consisted of structure, power supply, propulsion, communication, electronics and other support equipment.

Aiming the launch and timing the take-off had to be figured with precision. The scientists had to take into consideration the orbital speed of Earth and Venus around the sun, the Earth's rotation, and the movement of the sun as well as the gravitational pull of these bodies. Mariner II was lobbed into space in the opposite direction from its rendezvous point with Venus. The reason for this was that Earth and Venus are locked in solar orbit with Venus closer to the sun. When an orbiting body slows down, it is drawn inward by the sun's gravitational pull. Mariner II had to be fired in the opposite direction to lose some of the earth's orbital speed which it already had before it was even launched. This feat of marksmanship has been likened to hitting "a fast-flying clay pigeon from a spinning merry-go-round using a rifle fastened to the merry-go-round."

With its solar panel wings spread, the spacecraft created electric power for its instrumentation (by means of 9,800 solar cells) during its journey. Its high gain antenna pointed toward earth for communication. A complex system of sun and earth sensors, gyroscopes, and nitrogen gas jets kept Mariner in proper attitude. Other major equipment included an omni-antenna, other radio equipment, temperature controls and a 50-pound-thrust mid-course correction rocket system used to correct its course 1,490,000 miles out in space.

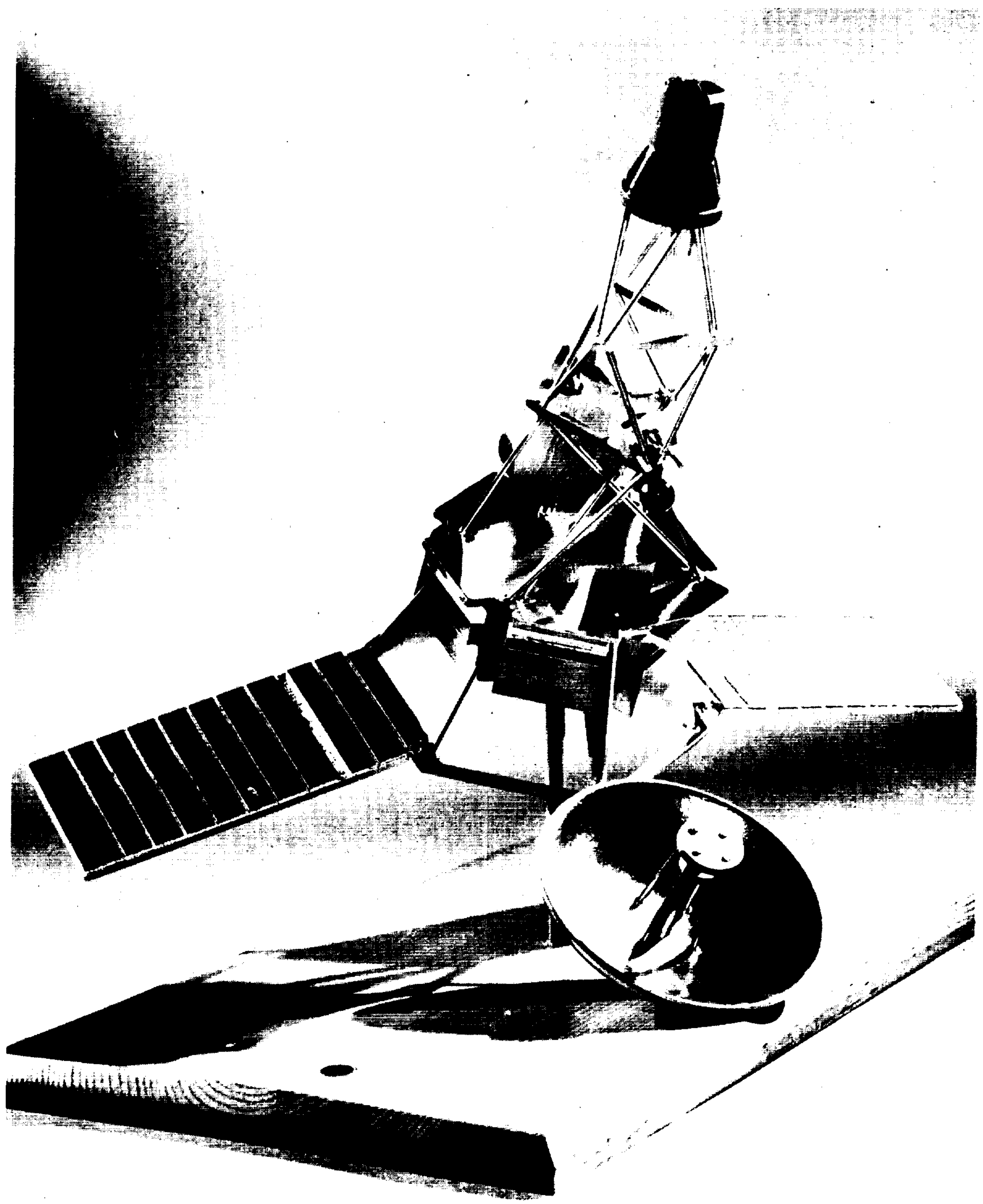
Mariner II's mission was officially completed when it passed Venus and joined the other planetoids in solar orbit. This Venus fly-by significantly advanced the world's knowledge about Venus and about interplanetary space. In addition to the 18 data readings covering the night and day side of Venus and the terminator which separates them, the spacecraft sent an abundance of information while enroute. It continued to transmit data about interplanetary space until January 3, 1963. When radio contact was lost, the Mariner was nearly 6 million miles beyond Venus and about 54 million miles from earth. The successful space bird rewarded its creators with 90 million bits (from <u>bi</u>nary digi<u>t</u> meaning a unit of information) which translated and interpreted with other experiments give a fascinating picture of "our morning and evening star".

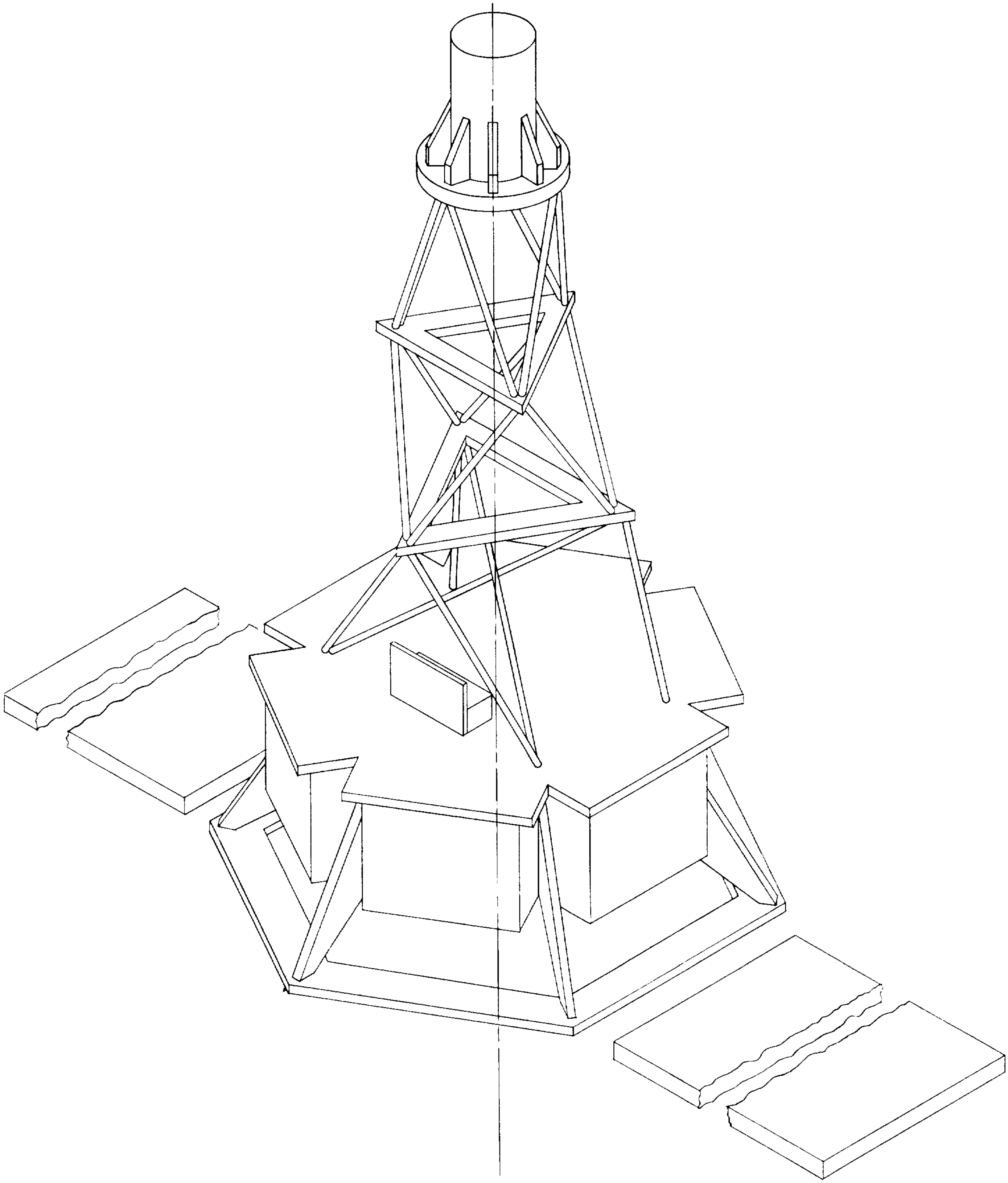
After months of study, a report was made to the world. Rich in carbon dioxide and poor in water vapor and oxygen, the atmosphere is hostile to life as we know it on earth. A continuous cloud cover 15 to 20 miles thick starts 45 miles above the surface. It creates a "greenhouse effect" by letting solar energy reach the surface but preventing much of the heat from escaping. The Mariner also reported that the temperature of the apparently dry and granular surface may be 800° F. Over it winds circulate dense gases compressed in an atmosphere 10 to 30 times heavier than ours. The speculation that the gases readily conduct heat around the planet may explain why the spacecraft found no temperature difference between the sunlit and the dark sides. The cloud temperature was found by the Mariner to be 200° F. at the base, -30° F. at the middle level and -60° F. at the upper level. It is speculated that the clouds are composed of condensed hydrocarbons like those found in smog.

No evidence of Venusian magnetic field nor any bands of radiation was reported by Mariner's instruments at the fly-by distance. The absence of such bands agrees with other observations that indicate a very slow rotation of the planet. Radar studies provide evidence that Venus rotates once each 225 earth days; thus Venus's day will equal its year. Studies also suggest that Venus rotates backwards with respect to earth. On Venus, then, the sun rises in the west and sets in the east.

The conditions on the Venusian surface suggest that the planet supports no life as we know it on earth, but biologists reserve judgment on the existence of lower forms of life in its upper atmosphere. The fundamental scientific question lies unanswered. Is there life on Venus?

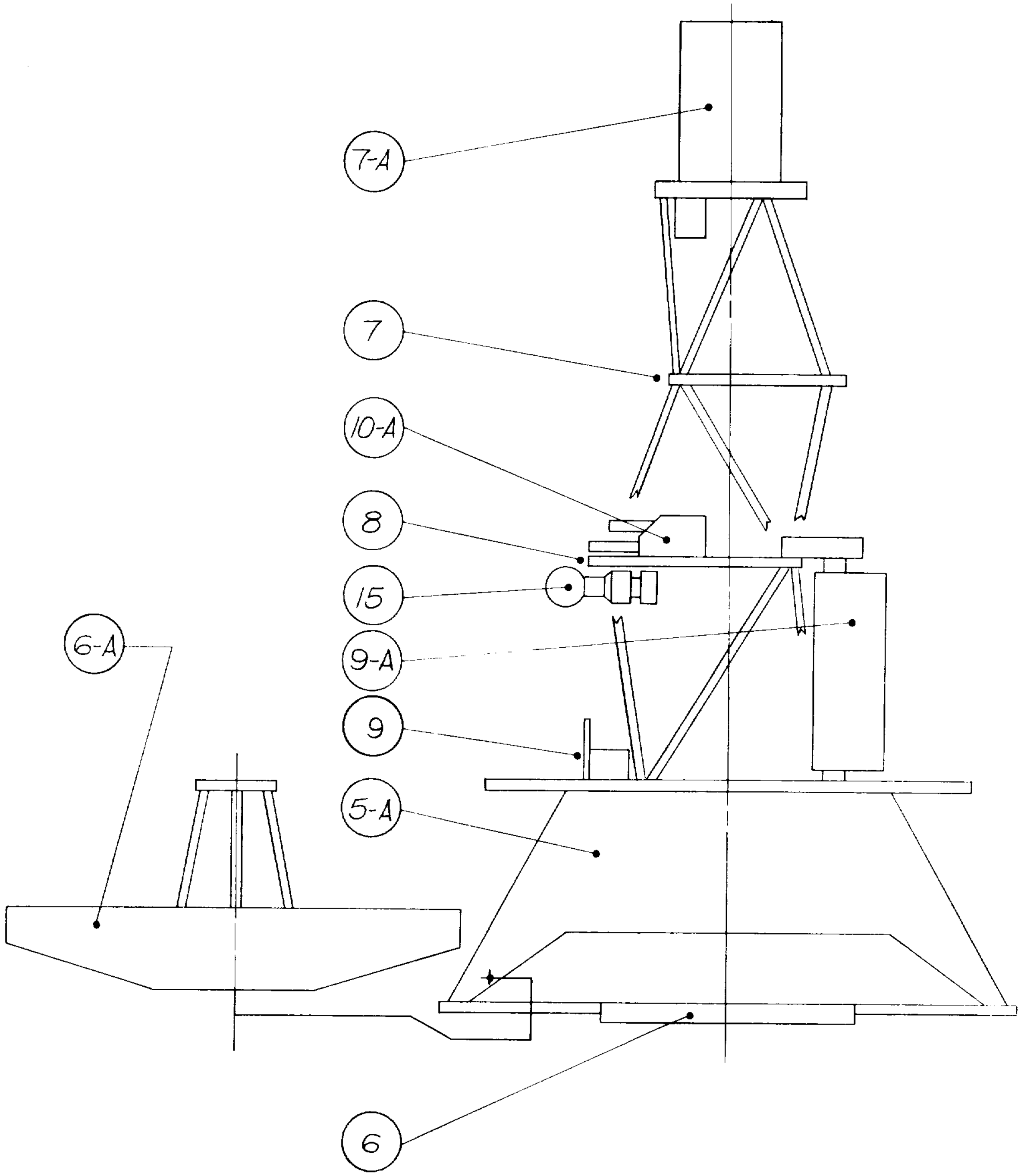
MARINER



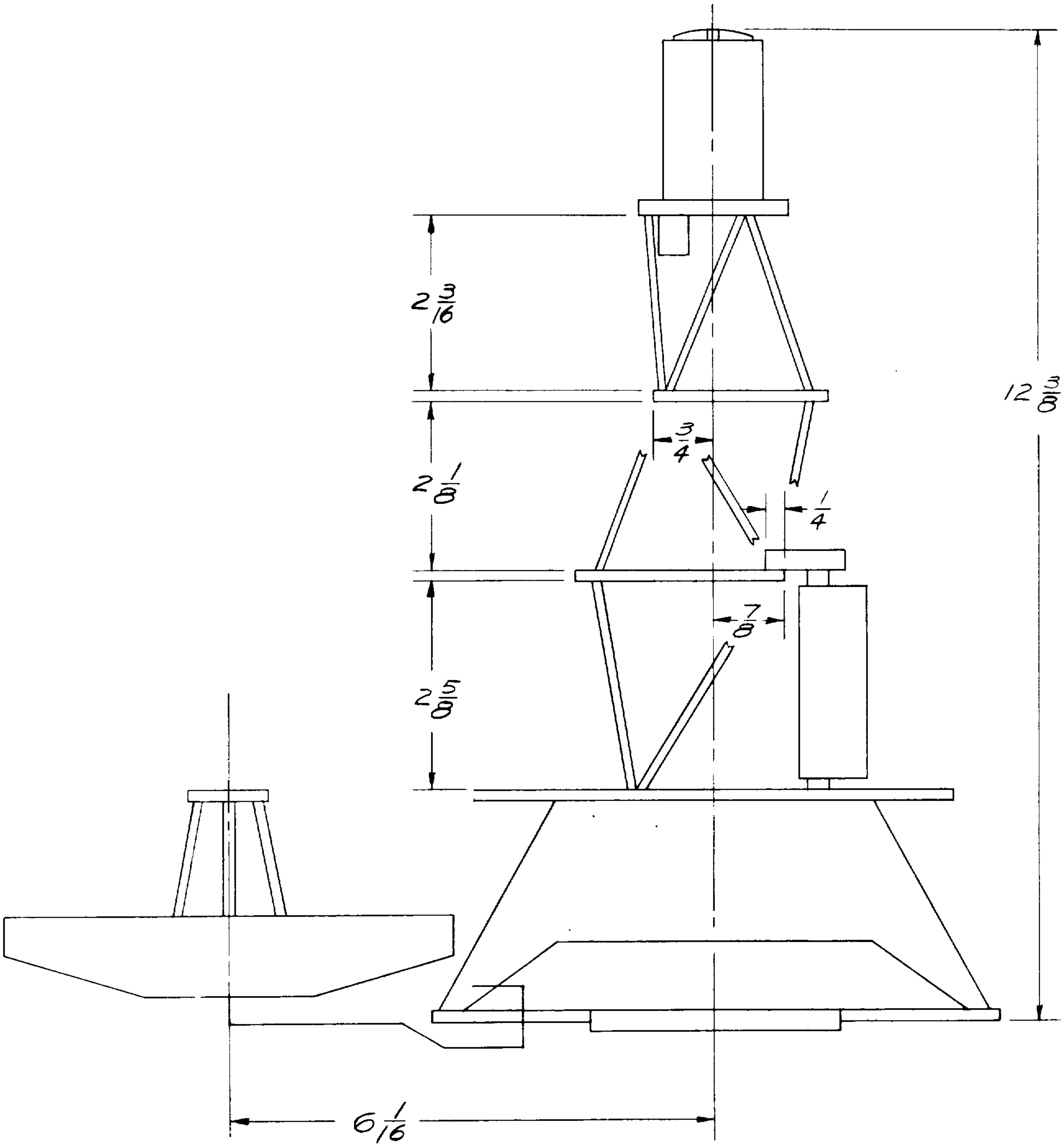


(1-A) MARINER

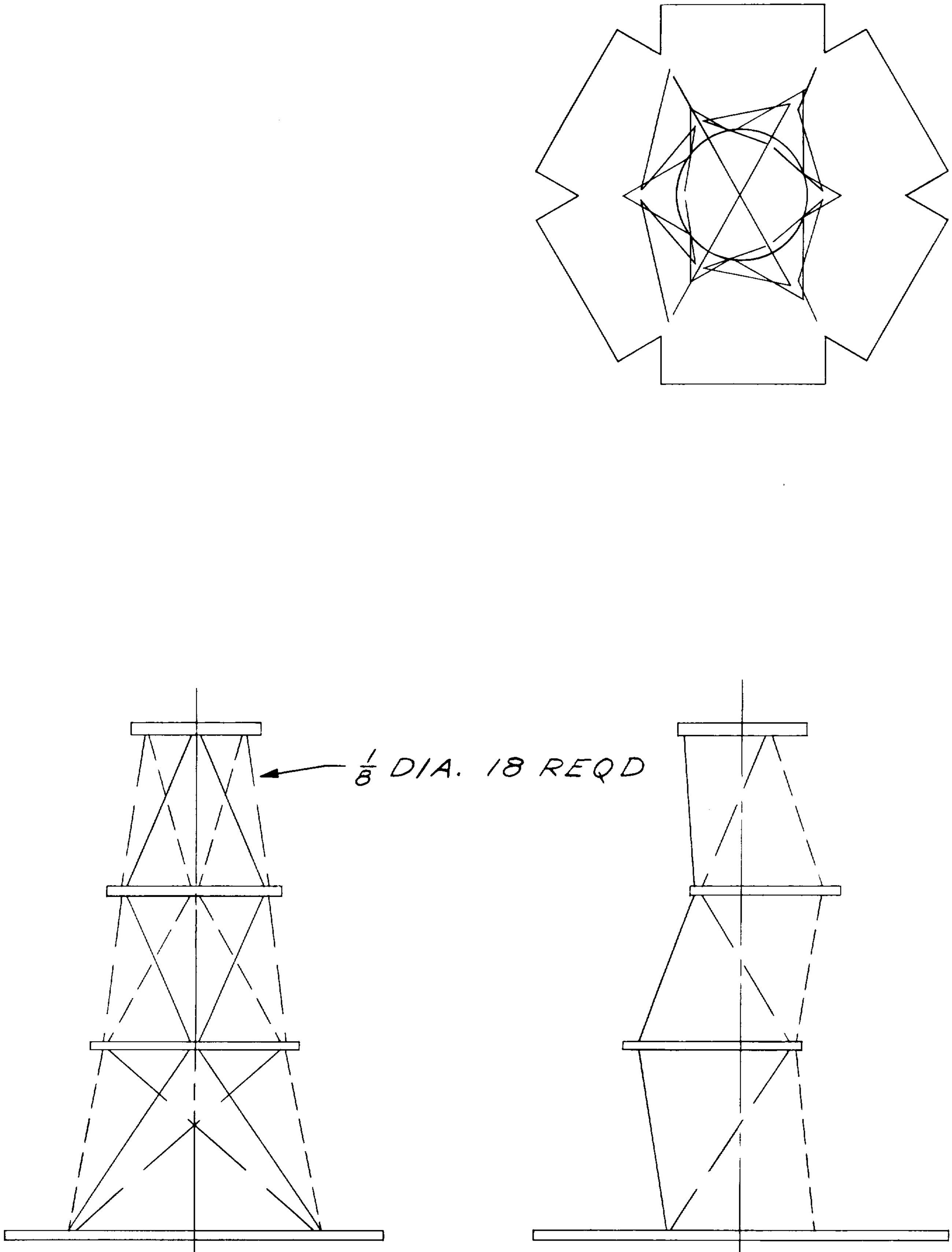
PARTIAL ELEVATION




2-A SIDE ELEVATION

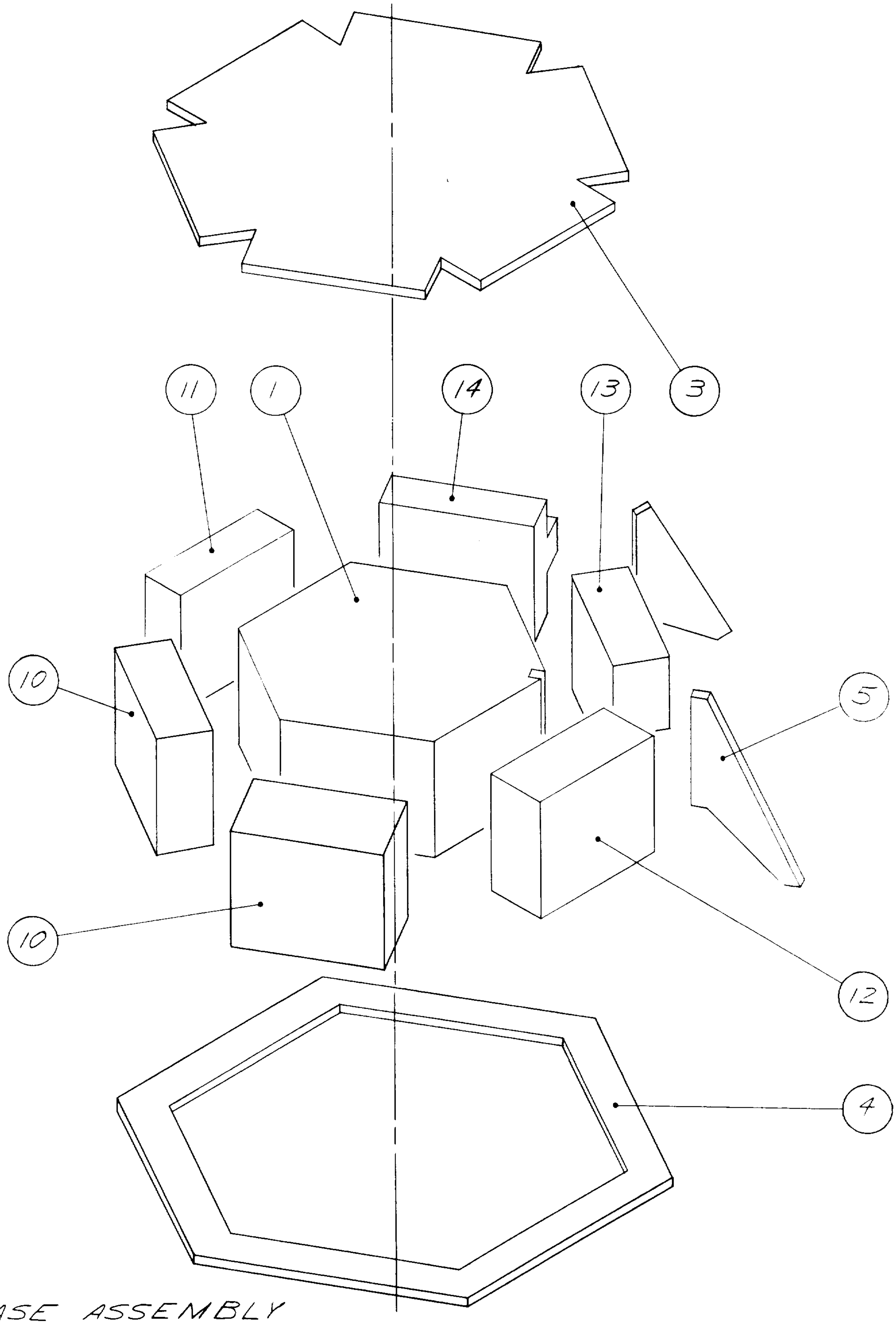



5-A SIDE ELEVATION

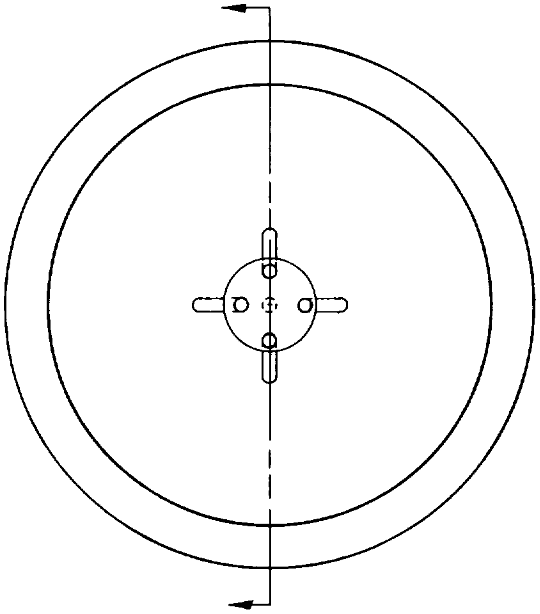


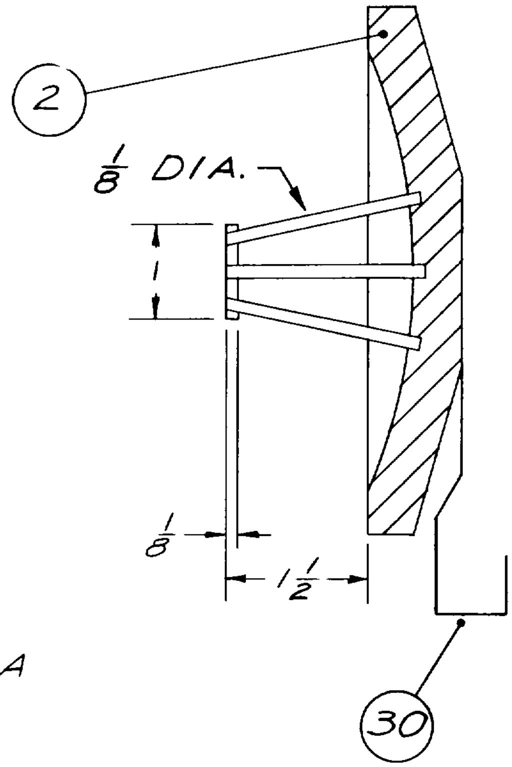

(4-A) FRONT

SIDE

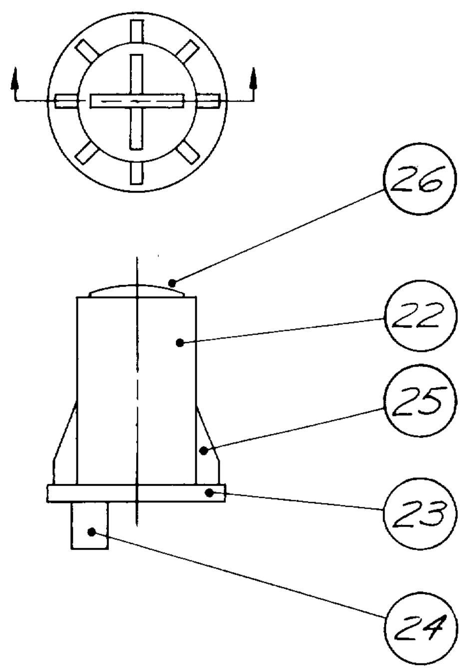



5-A BASE ASSEMBLY

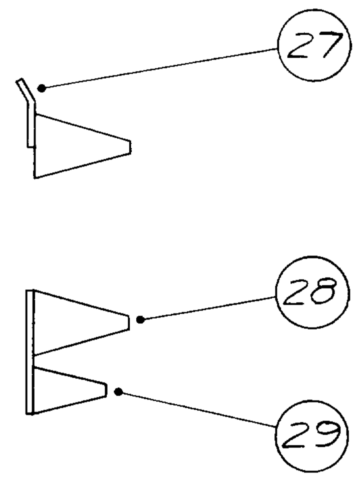




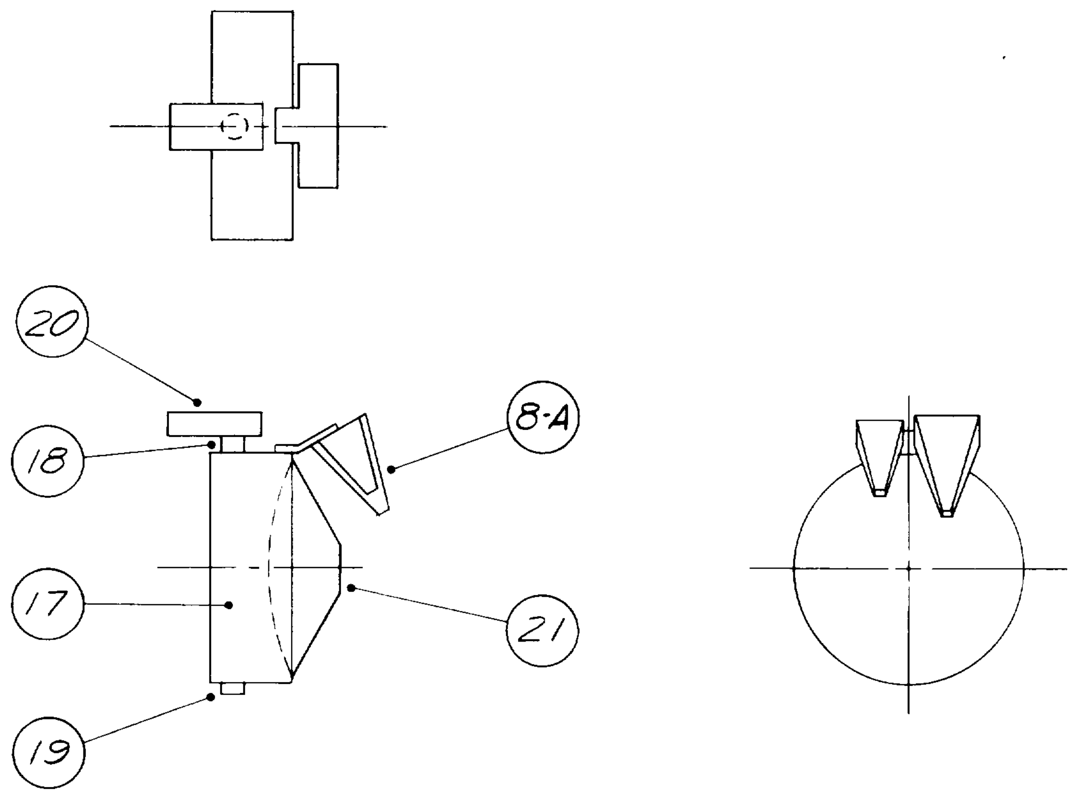

(6-A) HIGH - GAIN ANTENNA



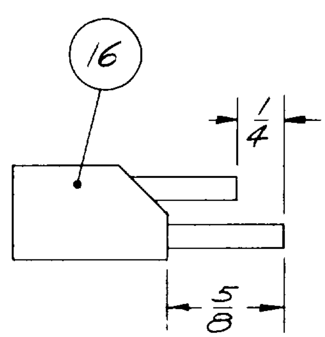

(7-A) OMNI - ANTENNA



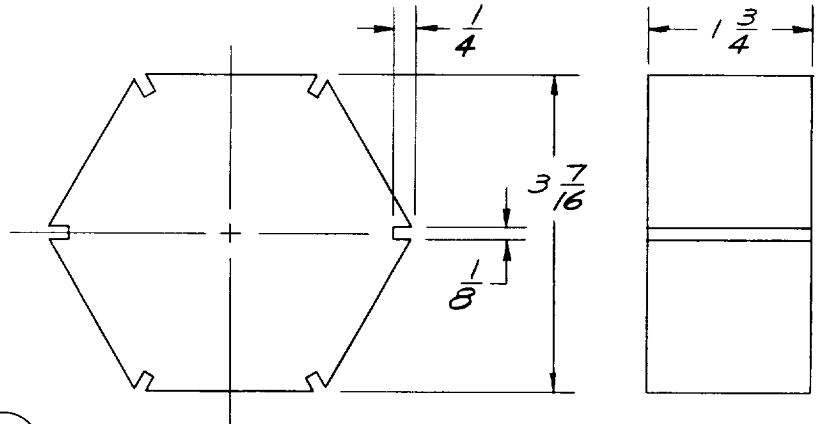

(8-A) RADIOMETER REFERENCE HORNS



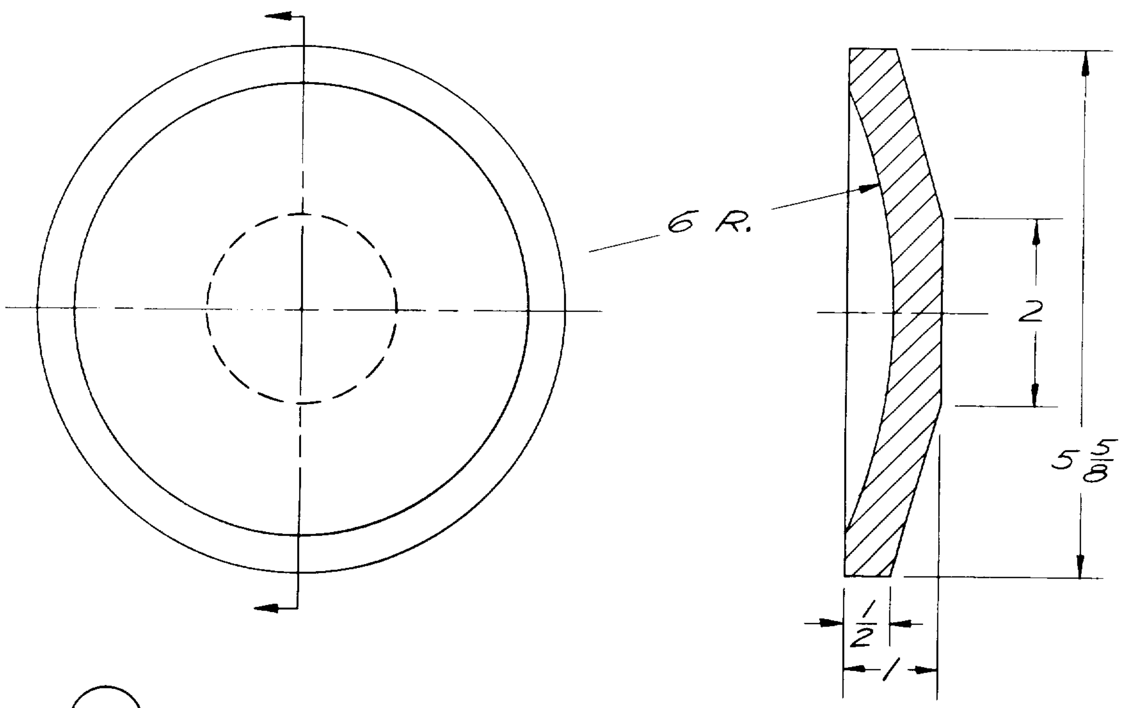

9-A RADIOMETER



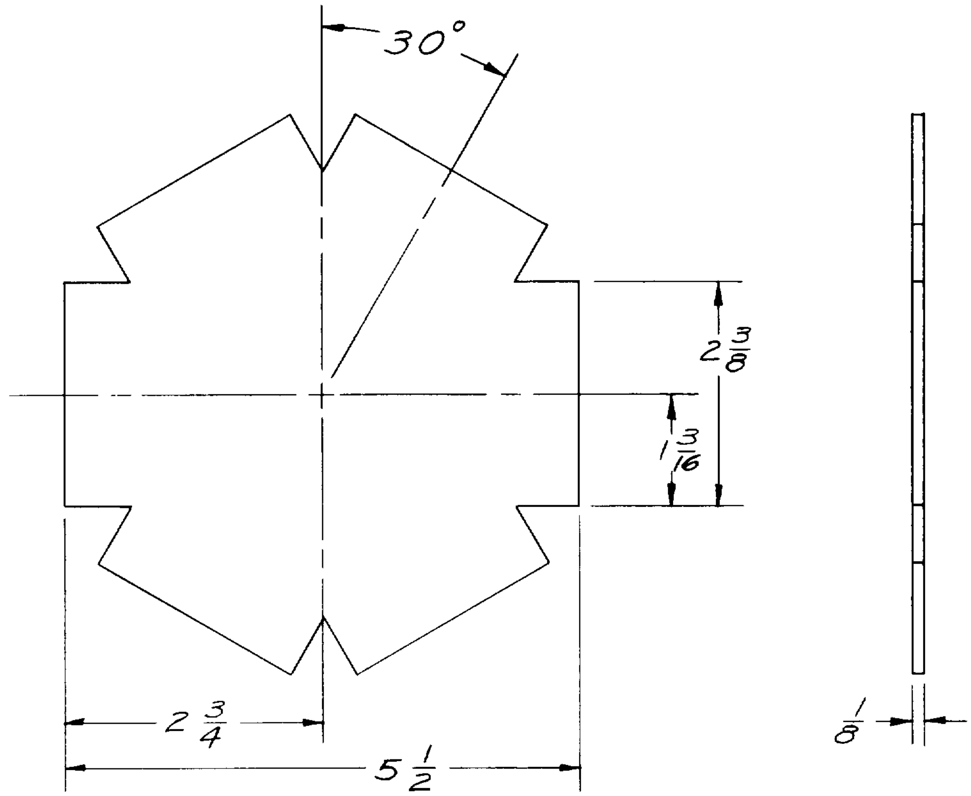

10-A COSMIC DUST DETECTOR



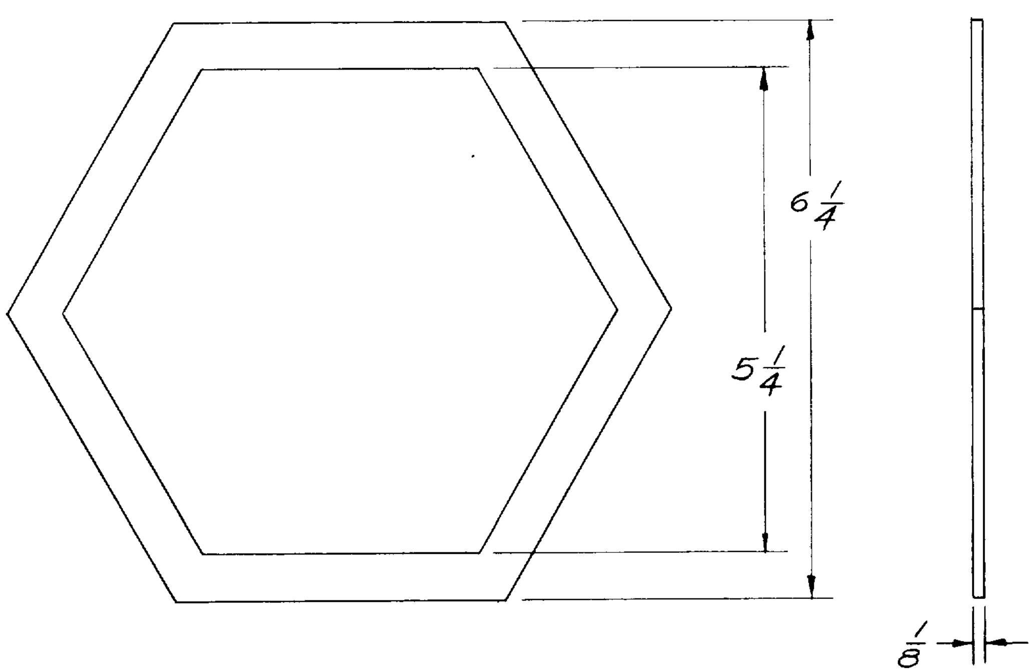

(1) CORE 1-REQD



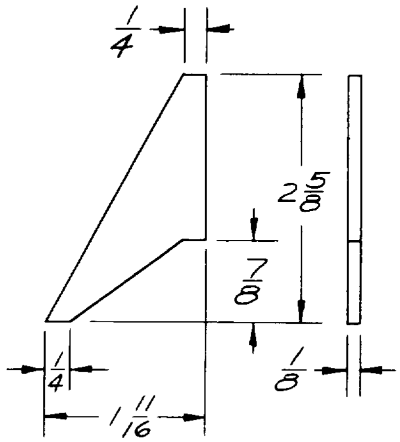

(2) HIGH-GAIN ANTENNA 1-REQD



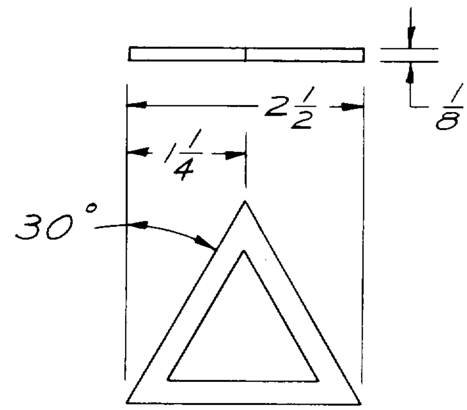

③ TEMPERATURE CONTROL SHIELD 1-REQD



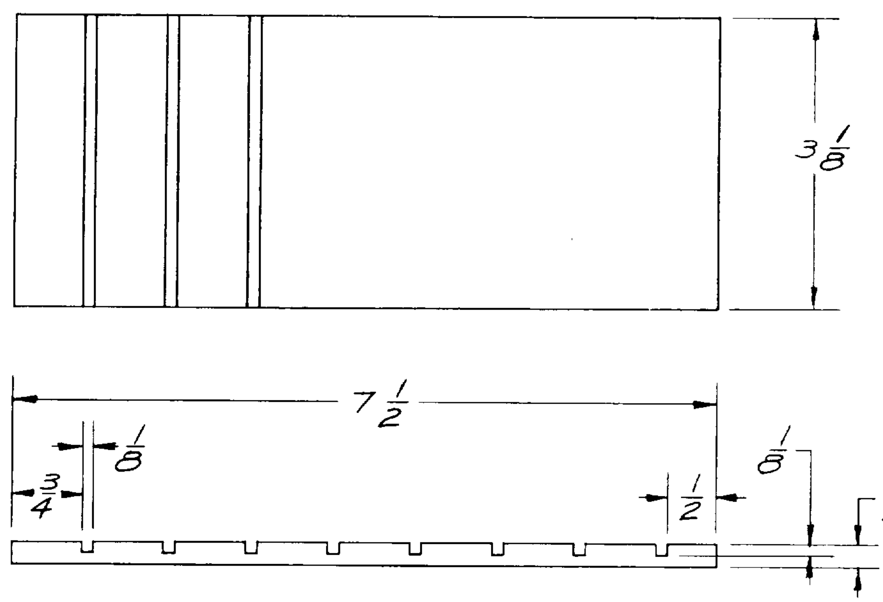

④ LEG BASE 1-REQD.



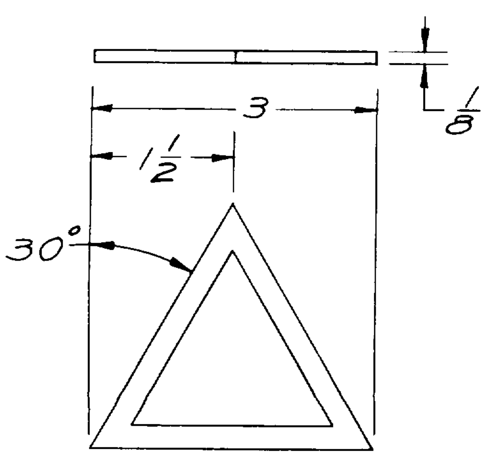

(5) LEG 6 - REQD



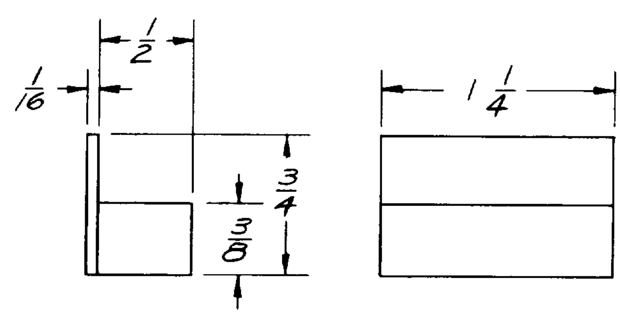

(7) UPPER ANTENNA SUPPORT 1-REQD



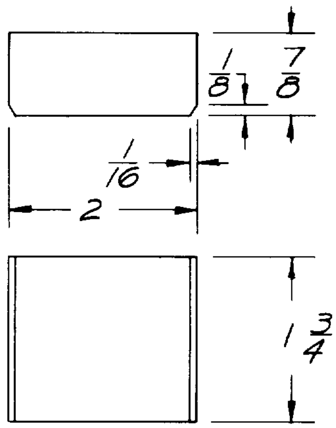

(6) SOLAR PANEL 2-REQD




(8) LOWER ANTENNA SUPPORT 1-REQD




(9) COSMIC DUST DETECTOR

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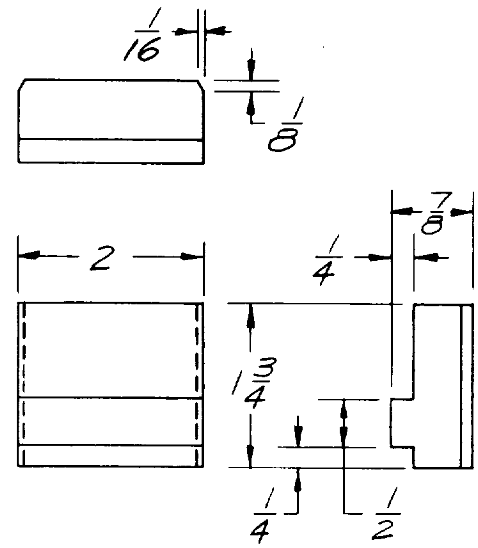


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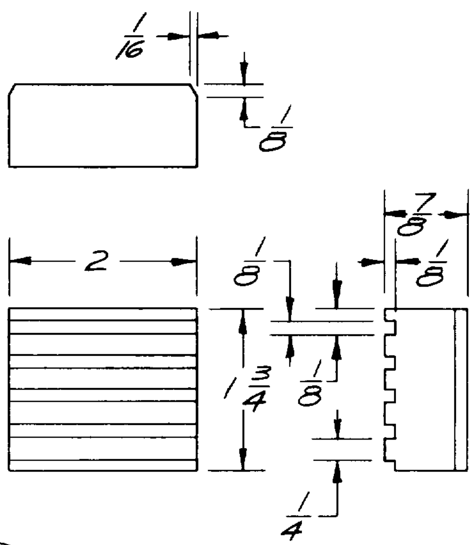


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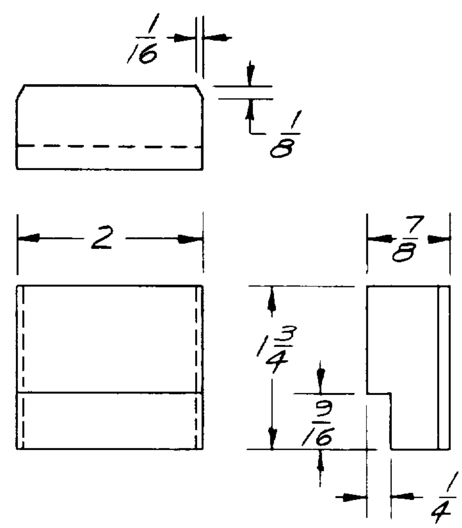


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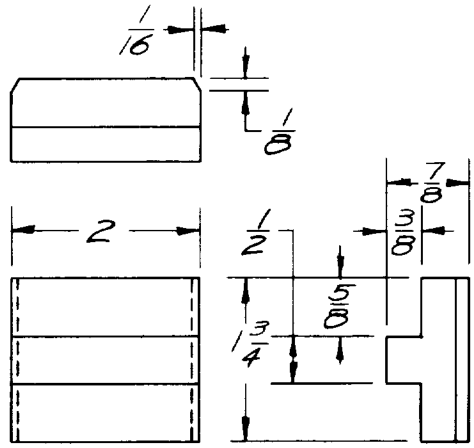
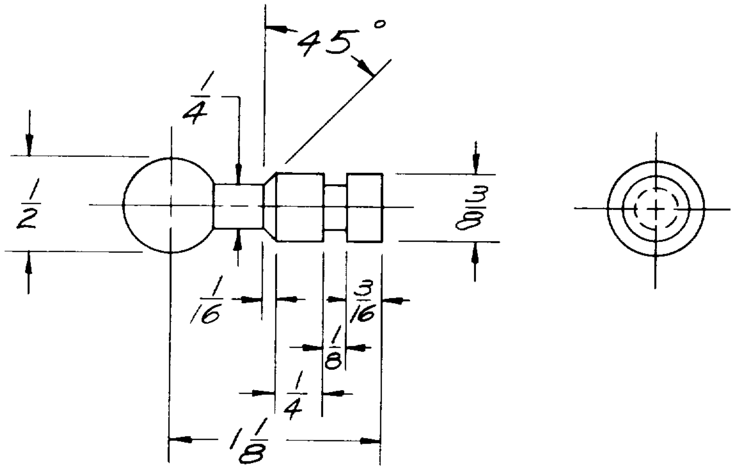
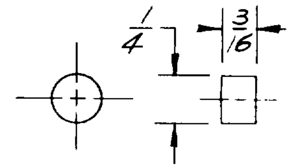


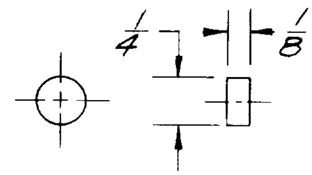

(14) TEMPERATURE CONTROL LOUVER 1-REQD



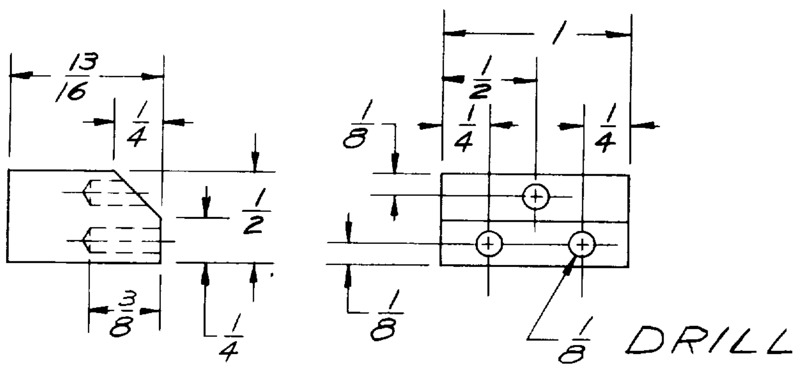
(15) ION CHAMBER 1-REQD



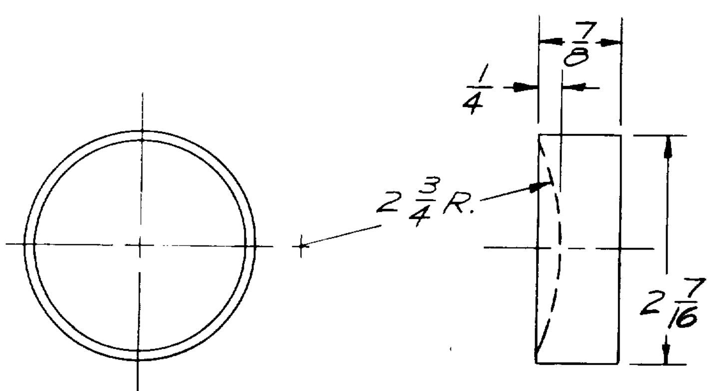
(18) SPACER 1-REQD



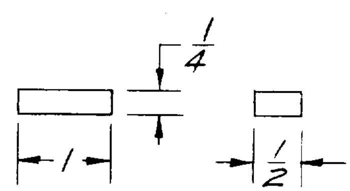
(19) SPACER 1-REQD




(16) PARTICLE FLUX DETECTOR 1-REQD




(17) RADIOMETER 1-REQD



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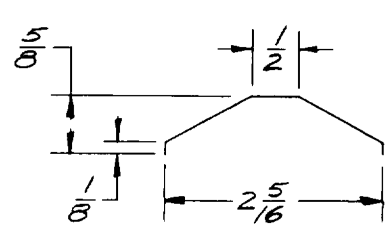
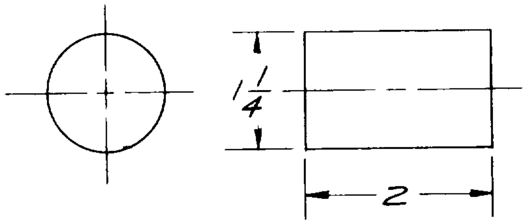
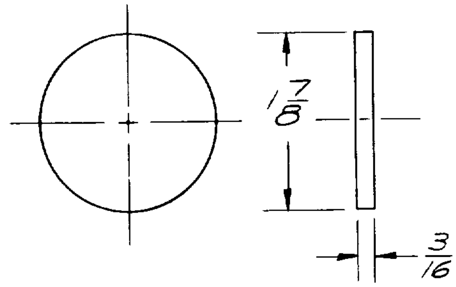


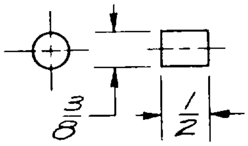
(21) WIRE 2-REQD



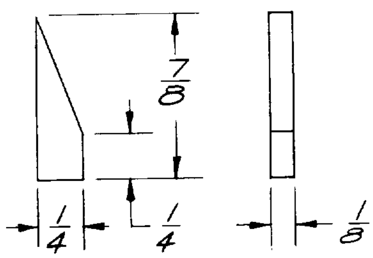

(22) OMNI SHAFT



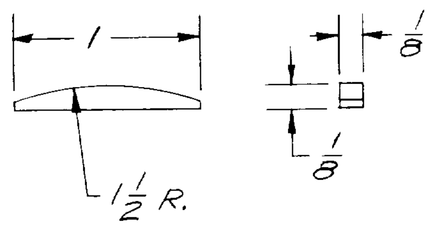

(23) OMNI BASE



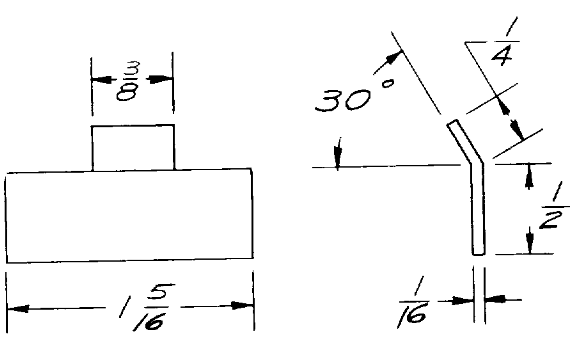

(24) SENSOR



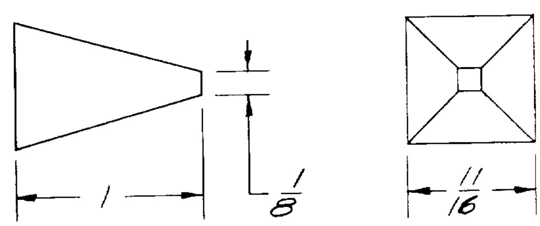

(25) OMNI BRACE 8-REQD
2 X



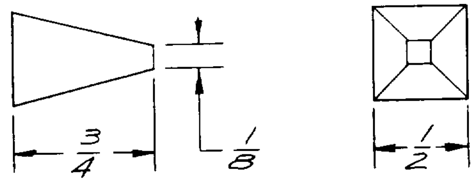

(26) OMNI TOP 2-REQD
2 X




(27) HORN BASE 2 X




(28) HORN 2 X




(29) HORN 2 X

RECOMMENDED MATERIALS FOR CONSTRUCTION

MARINER

| PART NUMBER | NUMBER REQUIRED | RECOMMENDED MATERIAL | COLOR |
|---|---|---|---|
| 1 | One | Wood - pine | Silver |
| 2 | One | Wood - maple | Gold |
| 3 | One | Wood - pine | Silver |
| 4 | One | Aluminum | Gold |
| 5 | Six | Aluminum | Gold |
| 6 | Two | Plastic | Silver-Purple |
| 7 | One | Wood - pine | Gold |
| 8 | One | Wood - pine | Gold |
| 9 | One | Wood - balsa | Gold |
| 10 | Two | Wood - pine | Silver |
| 11 | One | Wood - pine | Silver |
| 12 | One | Wood - pine | Silver |
| 13 | One | Wood - pine | Silver |
| 14 | One | Wood - pine | Silver |
| 15 | One | Wood - maple | Black |
| 16 | One | Wood - pine | Silver |
| 17 | One | Wood - maple | Silver |
| 18 | One | Dowel - rod | Silver |
| 19 | One | Dowel - rod | Silver |

RECOMMENDED MATERIALS FOR CONSTRUCTION

MARINER

| PART NUMBER | NUMBER REQUIRED | RECOMMENDED MATERIAL | COLOR |
|---|---|---|---|
| 20 | One | Wood - pine | Silver |
| 21 | Two | Wire | Silver |
| 22 | One | Wood - pine | Light Brown |
| 23 | One | Wood - pine | Light Brown |
| 24 | One | Dowel - rod | Light Brown |
| 25 | Eight | Balsa wood | Light Brown |
| 26 | One | Wood - pine | Light Brown |
| 27 | One | Aluminum | Silver |
| 28 | One | Wood - pine | Silver |
| 29 | One | Wood - pine | Silver |
| 30 | One | Wire | Gold |
| 31 | Two | Sheet metal | Gold |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

MARINER

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 1 | Wood or plastic | Layout and cut a hexagon to specified dimensions and "slot" to accommodate part no. 5 as indicated on detail no. 1 | Finish sand all surfaces | |
| 3 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | |
| 4 | Metal - sheet aluminum | Cut and shape to specified dimensions | Polish | |
| 5 | Metal - sheet aluminum | Cut and shape to specified dimensions | Polish | Subassemble parts no. 5,1 and 4 using epoxy resin |
| 10 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | Glue to part no.1 as specified on detail no. 5A |
| 11 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | Glue to part no.1 as specified on detail no. 5A |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

MARINER

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 12 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | Glue to part no.1 as specified on detail no. 5A |
| 13 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | Glue to part no.1 as specified on detail no. 5A |
| 14 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | Glue to part no.1 as specified on detail no. 5A |
| 7 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | |
| 8 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | |
| 22 | Wood - pine | Turn on lathe to specified dimensions | Finish sand | |
| 23 | Wood - pine | Cut and shape to specified dimensions | Finish sand | |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

MARINER

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 24 | Dowel - rod | Cut and shape to specified dimensions | Finish sand | |
| 25 | Balsa wood | Cut and shape to specified dimensions | Finish sand all surfaces | |
| 26 | Wood - pine | Cut and shape to specified dimensions | Finish sand | Glue parts no. 22,23,24,25 and 26 as indicated on detail drawing no.7A<br><br>Assemble parts no. 3,7 and 8 and subassemble no.7A using 1/8" dowel rod as indicated on detail nos. 1A,3A, and 4A |
| 9 | Wood - balsa | Cut and shape to specified dimensions | Finish sand all surfaces | Glue to part no.3 as indicated on detail no. 1A |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

MARINER

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 15 | Wood - maple | Turn on lathe to specified dimensions | Finish sand | Glue to 1/8" dowel rods supporting part no. 8 as indicated on detail no. 2A |
| 16 | Wood - pine | Cut and shape to specified dimensions. Layout and drill holes as specified | Finish sand all surfaces | |
| 10A | | | | Glue 1/8" dowels to part no. 16 as specified on detail no. 10A. Glue part no. 10A to part no. 8 as indicated on detail no. 2A |
| 17 | Wood - maple | Turn on lathe to specified dimensions | Finish sand all surfaces | |
| 18 | Dowel - rod | Cut to specified length | | Glue to part no. 17 using epoxy resin |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

MARINER

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 19 | Dowel - rod | Cut to specified length | | Glue to part no. 17 using epoxy resin |
| 20 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | Glue to part no. 18 using epoxy resin as indicated on detail no. 9A |
| 21 | Wire | Shape as specified on detail no. 21 | | Glue to part no. 17 as indicated on detail no. 9A using epoxy resin |
| 27 | Metal - sheet aluminum | Cut and shape to specified dimensions | | |
| 28 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | |
| 29 | Wood - pine | Cut and shape to specified dimensions | Finish sand all surfaces | |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

MARINER

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 8A | | | | Subassemble parts no. 27,28 and 29 as specified. Glue to part no. 9A using epoxy resin |
| 31 | Sheet metal | Cut and shape to specified dimensions | Finish all surfaces | |
| 6 | Plastic or wood (maple) | Cut and shape to specified dimensions | Finish all surfaces | Assemble to part no. 31 using brads. Glue part no. 31 to part no. 4 using epoxy resin |
| 2 | Wood - maple | Turn on lathe as specified on detail no. 2 | Finish sand | |
| 6A | | Complete fabrication of antenna as indicated on detail no. 6A | | |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

MARINER

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
| --- | --- | --- | --- | --- |
| 30 | | Using no. 16 wire construct hinge as indicated on detail no. 2A | | Attach to part no. 6A using epoxy resin. Secure remaining end to part no.5 so antenna will hinge into part no. 4 |
| | | | Paint parts no. 1,3,6,10,11,12, 13,14,16,17,18, 19,20,21,27,28 and 29 silver | |
| | | | Paint parts no.2 4,5,7,8,9,30 and 31 gold | |
| | | | Paint part no. 15 black | |
| | | | Paint parts no.22, 23,24,25 and 26 light brown | |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

MARINER

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| | | | Paint solar cell surfaces on part no. 6 purple | |

A P O L L O

"------- no more than the man in the moon." In spite of the unbelievers, there may be a man in the moon.

No one knows where or when the idea of space travel started. This dream of exploring the moon probably dates back to the time when man first realized that it was not part of his own planet. One of the first science fiction stories, a novel of a moon journey, was written by Lucian of Samos in the middle of the second century A.D. A period of 1500 years passed before another space travel story appeared. Francis Godwin wrote about a trip to the moon by bird propulsion in 1638. In more modern times, the early 19th century, Jules Verne wrote how space exploration would be accomplished. H. G. Wells in his War of the Worlds fascinated and frightened many.

In an enterprise such as the exploration of space, a clear-cut goal is necessary for impetus, order and efficiency. The relative nearness of the moon makes it the logical place in space where the men and equipment for future and more distant space travel can be tested. Little as we know about the moon, it still exceeds our knowledge of any other celestial bodies.

Because of the importance for night illumination, the ancients gave a great deal of attention to the moon's motions. The exactitude of the observations made was in advance of those in the other physical sciences. As early as the second century B.C., Hipparchus discovered the eccentricity of the moon's orbit. He determined the inclination of the orbit to the ecliptic and advanced the theory that the motion of the moon is uniform in circular orbit with the moon placed eccentrically. No new theory was introduced until the middle of the seventeenth century when Newton advanced his gravitational theory. In this century E. W. Brown introduced a completely new theory. His set of tables first used in 1923 will likely be used throughout the twentieth century.

The surface of the moon has also been a subject of continuous telescopic study since the time of Galileo. With large telescopes it is now possible to see an area less than a mile square. Telescopic observers have drawn detailed descriptions of the lunar surface and have laid its features down on maps. These together with photographs give a good indication of the moon's surface. It is believed now that the whole visible surface is rough and mountainous. The most striking features are the craters scattered over the surface with great profusion and frequently overlapping. Meteorites striking the moon are believed to have formed these craters. Erosion of the lunar surface may be the result of electrostatic charge by high energy solar radiation.

Among the other information gathered that will affect our exploration is the belief that the moon is devoid of air and water. No meteorological variations such as our weather is probable. The change by the direct action of the sun's rays indicates an enormous range in the temperature of the surface. It also means that an artificial earth environment must be a necessary equipment of the moon explorers.

In spite of our powerful telescopes, earth's life-giving atmosphere clouds our vision. The Ranger and the Surveyor programs will gather information above its shimmering moving layer before a manned moon exploration will be attempted. However, the dream of space exploration has now taken on a more concrete aspect. By the decision of the elected representatives of the people in the United States, Project Apollo is under way. The objective of this project is to develop the ability to explore the moon before the end of this decade.

Besides the gathering and analyzing of information, the competences necessary for the lunar exploration must be developed. At present there are three manned space flight programs ---- Mercury, Gemini, and Apollo. They constitute a step-by-step program to develop a broad capability for the manned exploration of space.

Project Mercury established adequately man's ability to perform effectively in the environment of orbital flight and developed the foundation of a manned space flight technology.

Operational proficiency and the development of new techniques including rendezvous will be gained in Project Gemini.

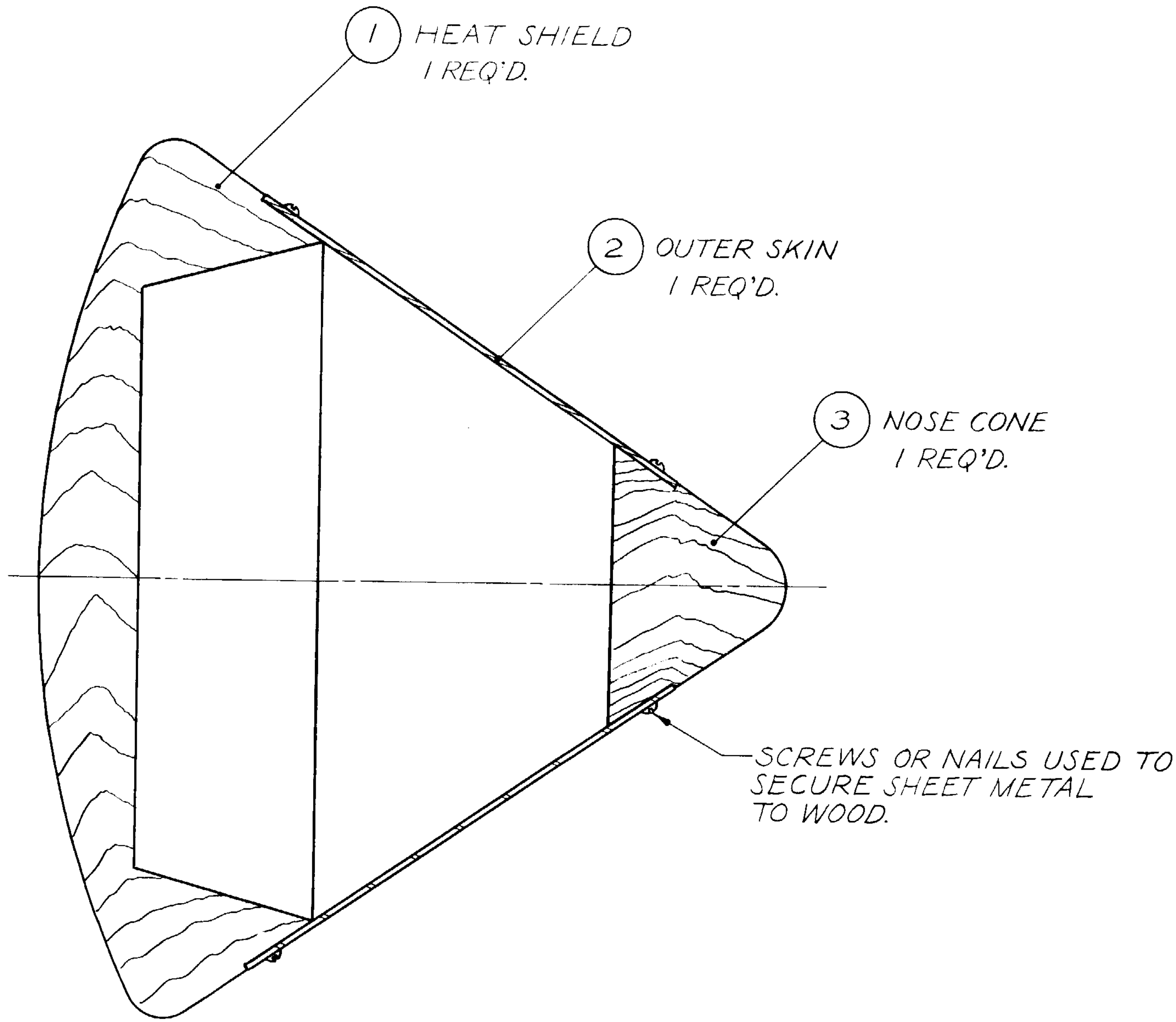
Finally in Project Apollo, three astronauts will be sent to explore the moon. The moon explorers will start their expedition by boarding an 80 feet tall spaceship perched atop Saturn V, a multistage rocket. This spaceship will consist of three modules. The Command Module will house the three astronauts on the trip to and from the moon and serve as the control center. The Service Module will contain the life support system and the propulsion unit for mid-course correction and injection into and out of lunar orbit. The Lunar Excursion Module will transport the explorers to the surface of the moon and back to rendezvous with the Command Module in its orbit around the moon. In addition, a launch escape rocket system will be attached to the top of the Command Module in the event of trouble during the initial phase of the flight.

After the checkout, Apollo will be blasted to a speed of 25,000 miles per hour on a trajectory that will carry it to the vicinity of the moon in about 2 1/2 days. On arrival near the moon, it will be maneuvered into lunar orbit. Two of the three astronauts will then climb into the Lunar Excursion Module, separate from the rest of the spaceship and descend to the surface. After exploring the planned area for about 24 hours, the two explorers will rejoin the third crewman for the return back to earth. Leaving the empty Lunar Excursion Module circling the moon, the Service Module will provide the thrust for the spaceship's return trip. This module will be in turn jettisoned before re-entry into the atmosphere. The Command Module will re-enter alone and descend by parachute.

Today, moon and earth are closer in time than Europe and America were when Columbus set sail toward the unknown. Who knows what wonders will be found by the crewmen of the Apollo when they blast off toward the unknown.

APOLLO

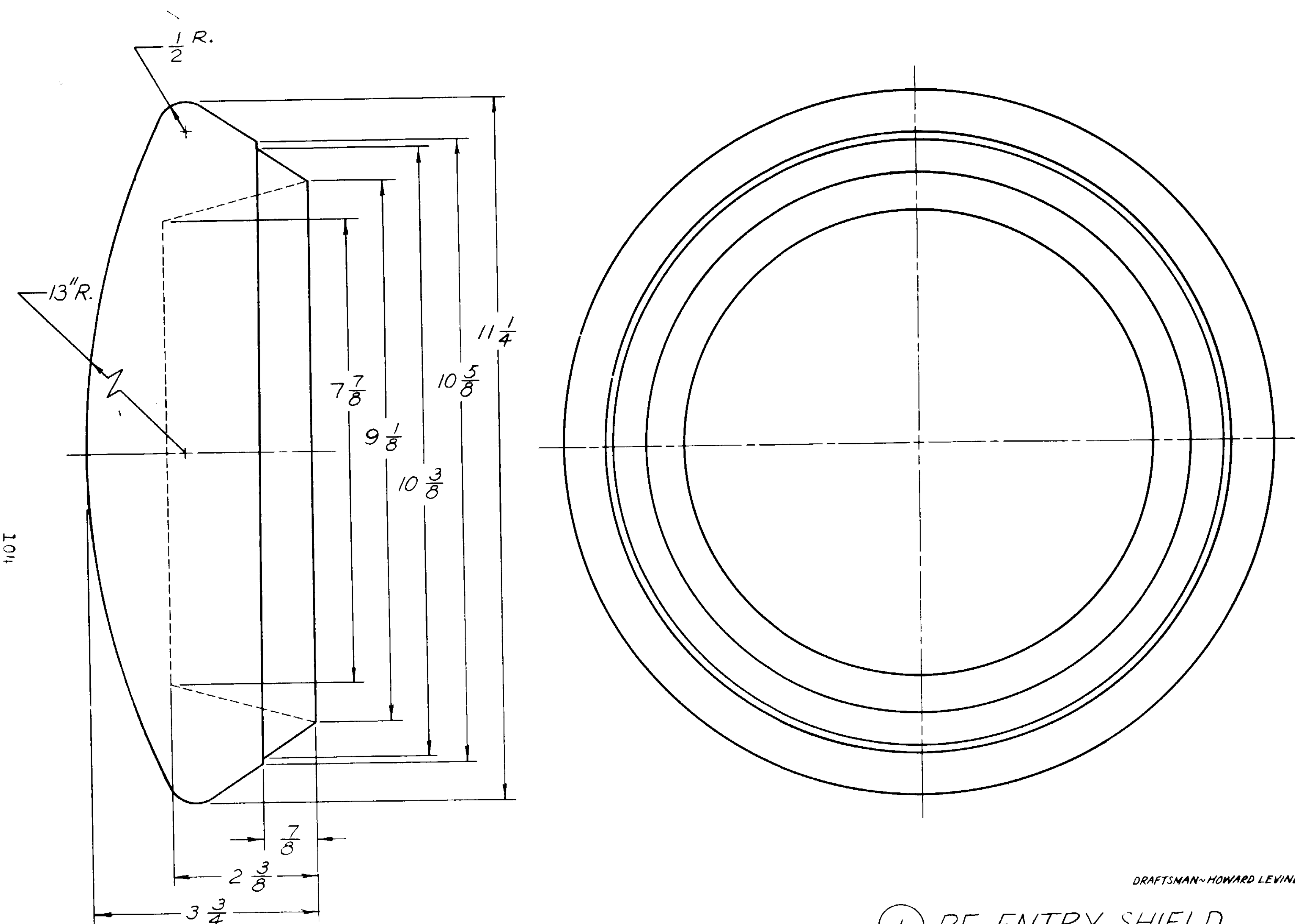
# APOLLO CONSOLE




ASSEMBLY - FULL SECTION

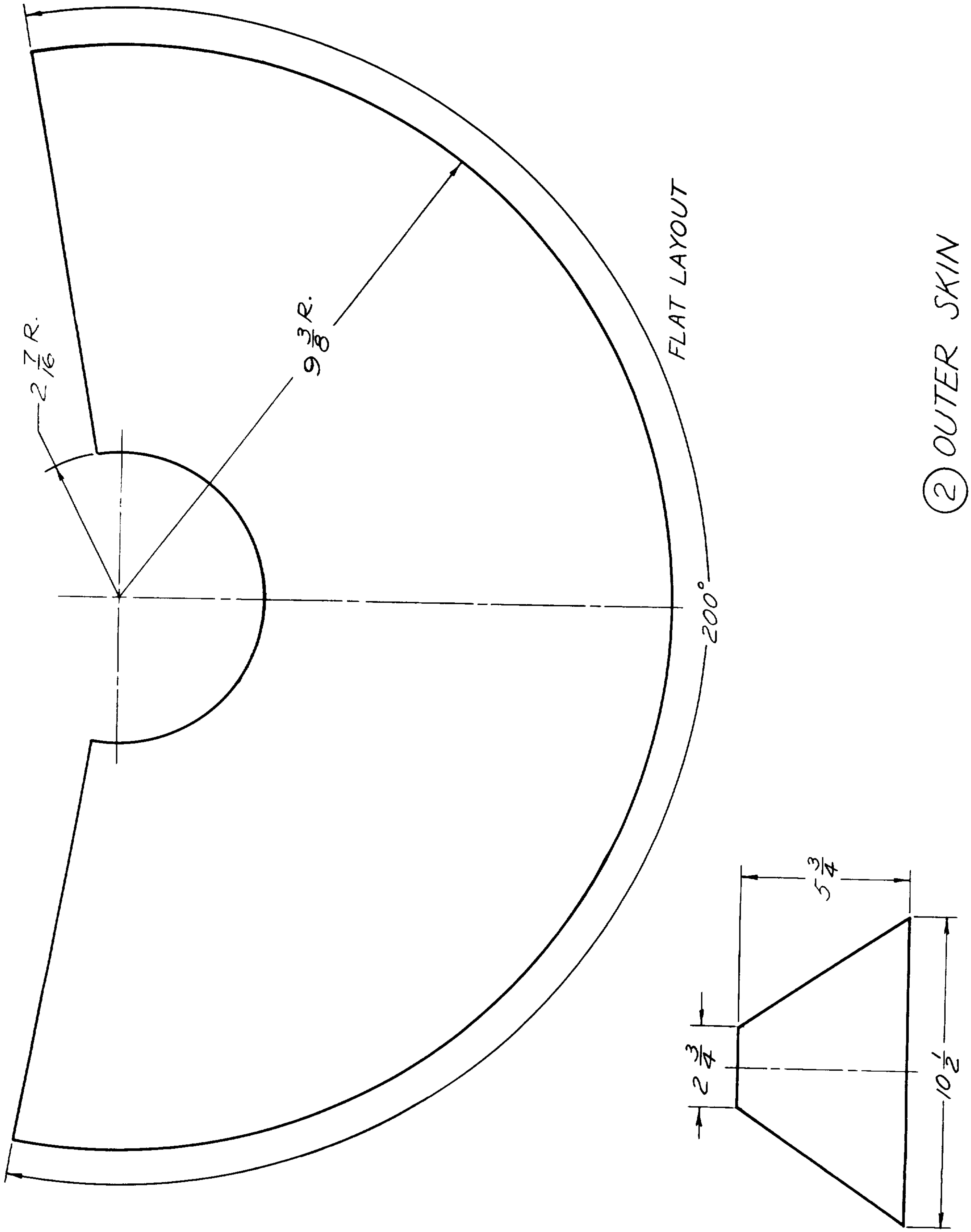
DRAFTSMAN~HOWARD LEVINE~1964

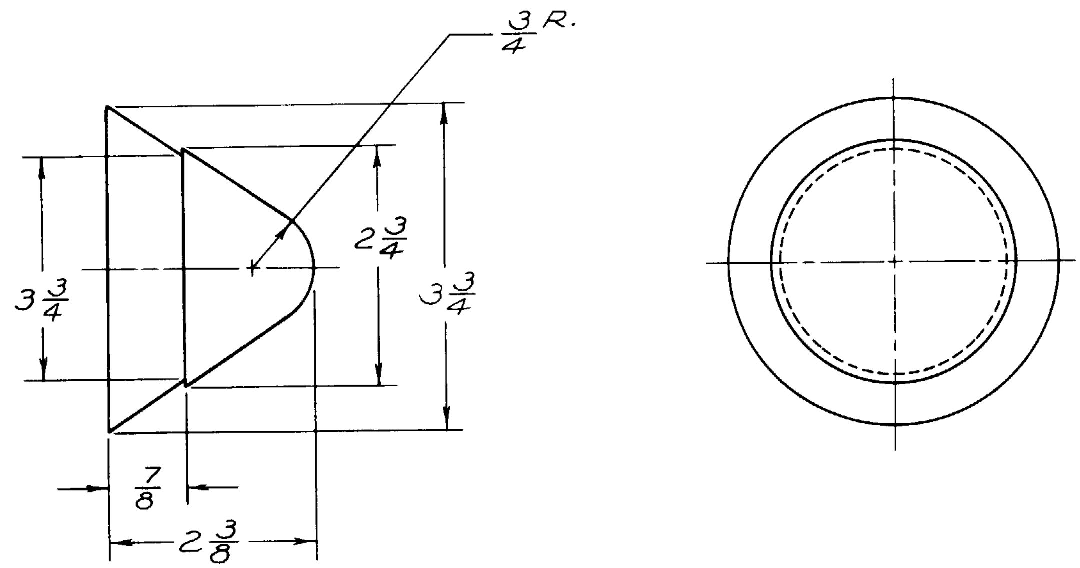
APOLLO~COMMAND MODULE




DRAFTSMAN ~ HOWARD LEVINE ~

(1) RE-ENTRY SHIELD


2 7/16 R.
9 3/8 R.
200°
FLAT LAYOUT
② OUTER SKIN
5 3/4
2 3/4
10 1/2
FORMED VIEW~HALF SIZE




(3) NOSE CONE

RECOMMENDED MATERIALS FOR CONSTRUCTION

APOLLO

| PART NUMBER | NUMBER REQUIRED | RECOMMENDED MATERIAL | COLOR |
|---|---|---|---|
| 1 | One | Wood or aluminum | White |
| 2 | One | Metal - sheet aluminum or cold rolled steel | White |
| 3 | One | Wood or aluminum | White |

RECOMMENDED PROCEDURE FOR CONSTRUCTION

APOLLO

| PART NO. | SUGGESTED MATERIALS | FABRICATION TECHNIQUE | SURFACE TREATMENT | ASSEMBLY RECOMMENDATIONS |
|---|---|---|---|---|
| 1 | Wood or cast aluminum | Turn on lathe to specified dimensions | Finish sand or polish surface | |
| 2 | Metal - sheet aluminum or sheet steel | Layout and fabricate to specified dimensions | | |
| 3 | Wood or cast aluminum | Turn on lathe to specified dimensions | Finish sand or polish surface<br>Paint white | Assemble parts no. 1, 2 and 3 |

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## Space Terms

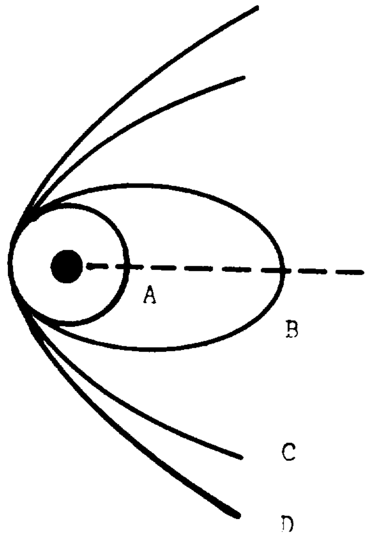
| | |
|---|---|
| Acceleration: | the rate of increase of velocity |
| Aerospace: | the Earth's envelope of air and the space above it, two separate entities considered as a single realm for activity in launching, guidance and control of vehicles which will travel in both realms |
| Aphelion: | the point at which a planet or other celestial object is farthest from the sun in its orbit about the sun |
| Apogee: | the point or position at which a moon or an artificial satellite in its orbit is farthest from its primary |
| Artificial Satellite: | a man made object placed in orbit |
| Atmosphere: | the body of air surrounding the earth; also the body of gases surrounding or comprising any planet or other celestial body |
| Booster: | a propulsion unit used in initial stage of flight |
| Burnout: | the point in time or in the missile trajectory when propellant is exhausted or cut off resulting in end of combustion of fuels in the rocket engine |
| Celestial Mechanics: | the study of motion in space |
| Centrifugal Force: | the apparent force tending to carry an object away from a center of rotation |
| Cislunar: | space between earth and moon |
| Deceleration: | negative acceleration (slowing down) |
| Eccentricity: | the degree of diviation from a circular orbit |
| Ecliptic: | the plane of Earth's orbit around sun |

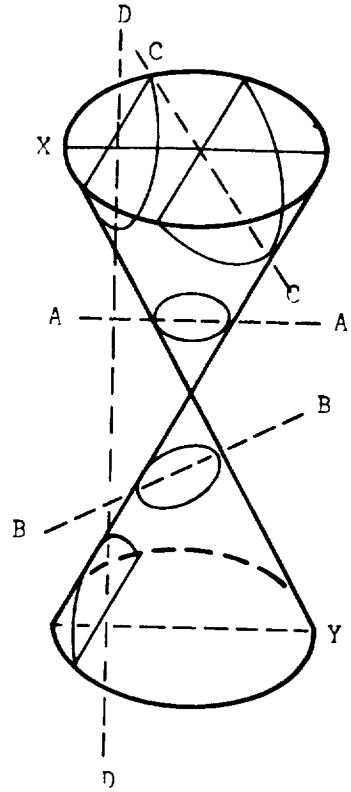
| | |
|---|---|
| Escape Velocity: | the velocity which if attained by an object will permit it to overcome the gravitational pull of the Earth or other astonomical body and to move into space |
| Exosphere: | the outermost layer of the atmosphere where collisions between molecular particles are so rare that only the force of gravity will return escaping molecules to the upper atmosphere |
| Free Fall: | the motion of any unpowered body traveling in a gravitational field |
| G or G-force: | force exerted upon an object by gravity or by reaction to acceleration or decleration; one G is the measure of the gravitational pull required to move a body at the rate of about 32.16 ft. per sec. |
| Interplanetary: | between planets |
| Interstellar: | between stars |
| Ion: | an atom that has lost or acquired one or more electrons |
| Ionosphere: | a layer of atmosphere characterized by ionized gases |
| Lunar: | of or pertaining to the moon |
| Mass: | the quantity of matter in an object |
| Mass Ratio: | the ratio of a rocket's mass to launch to its mass at burnout |
| Orbit: | path of a body relative to its primary |
| Orbital Velocity: | the speed of body following a closed open orbit |
| Payload: | useful cargo |
| Perigee: | the point at which a moon or an artificial in its orbit is closest to its primary |
| Perihelion: | the point in an elliptical orbit around the sun which is nearest the sun |
| Probe: | an unmanned projectile sent into space to gather information |
| Primary: | the body around which a satellite orbits |
| Propellant: | a liquid or solid substance burned in a rocket for the purpose of developing thrust |

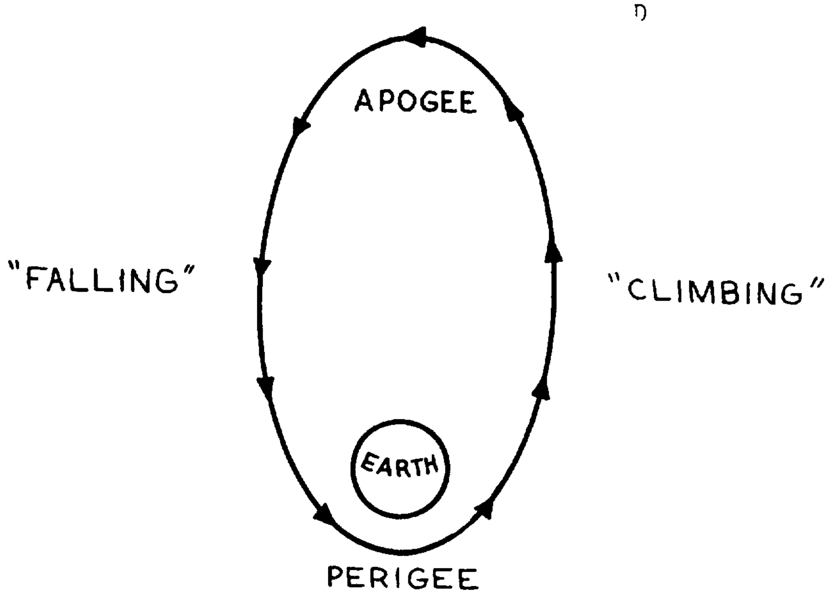
| | |
|---|---|
| Rendezvous: | the event of two or more aerospace vehicles meeting in flight at a preconceived time and place |
| Retrorocket: | a rocket fitted on or in a vehicle that discharges counter to the direction of flight, used to retard forward motion |
| Revolution: | orbital motion around a primary |
| Rotation: | rotary motion on an axis |
| Satellite: | a body moving around a primary |
| Satelloid: | an artificial body or vehicle like an artificial satellite except that it is under engine thrust (intermittent or continuous) in its orbit |
| Space: | that part of the universe between celestial bodies |
| Telemetering: | the technique of recording space data by radioing an instrument reading from a rocket to a recording machine on the ground |
| Terrestrial: | of or pertaining to the Earth |
| Thermal Barrier: | the zone of speed at which friction heat generated by rapid passage of an object through the atmosphere exceeds endurance compatible with the function of the object |
| Thrust: | the amount of "push" developed by a rocket, measured in pounds |
| Trajectory: | the path described by a space vehicle |
| Translunar: | beyond the moon |
| Weightlessness: | lack of resistance to the influence of gravity |
| Zero Gravity: | the complete absence of gravitational effect existing when the gravitational attraction of a primary is exactly nullified or counterbalanced by inertial force |

Vocabulary words from -
The Challenge of Space Exploration
by: NASA

Can You Talk the Language of the Aerospace Age?
Air Force Recruiting Service



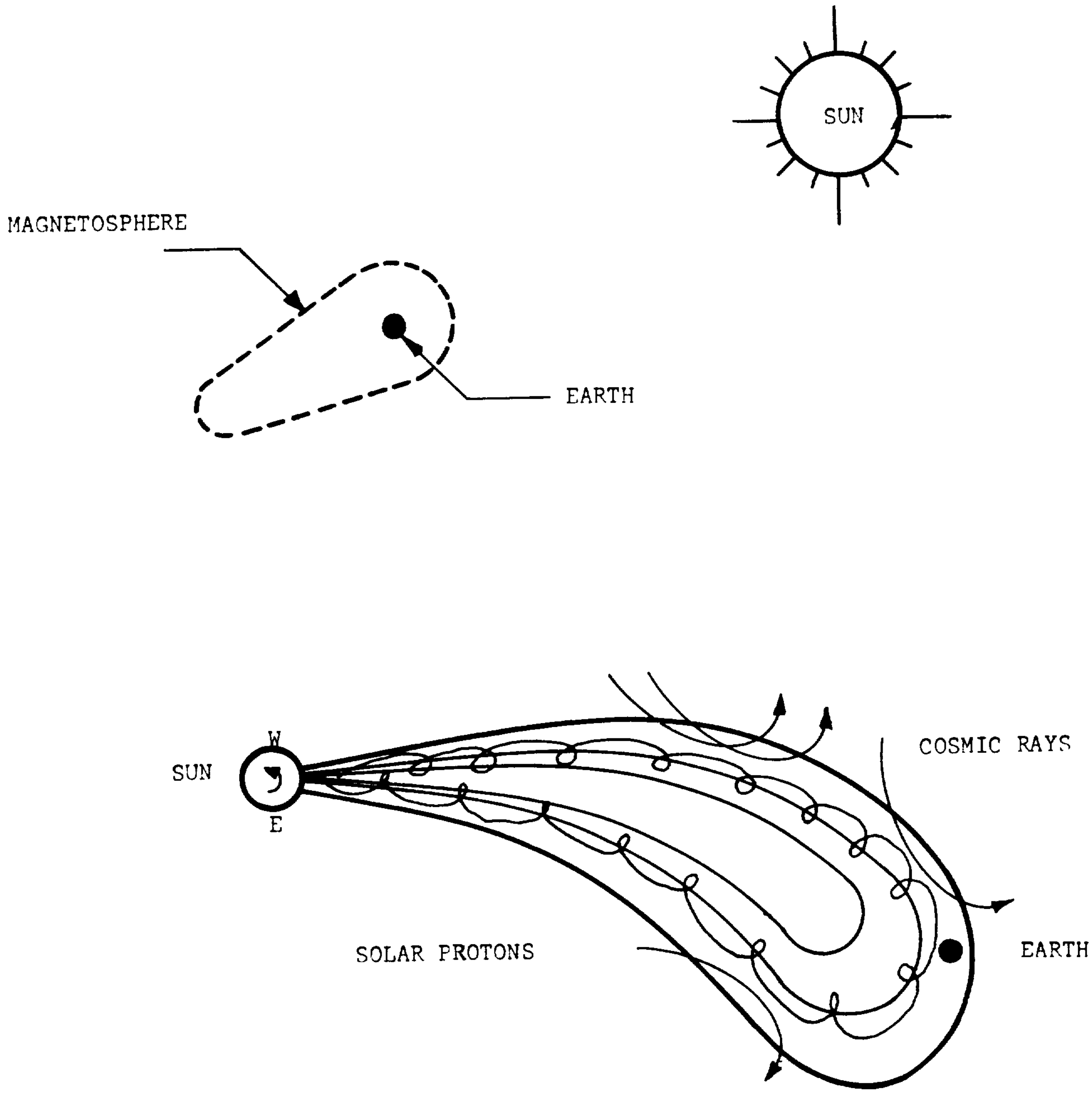

A CIRCLE

B ELLIPSE

C PARABOLA (parallel to line XY)

D HYPERBOLA

from: The Challenge of Space Exploration, NASA




PROPAGATION OF SOLAR DISTURBANCES
FROM SUN TO EARTH

from: The Explorer Satellites, NASA Facts

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SPACECRAFT CONSTRUCTION

NASA PROJECT

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